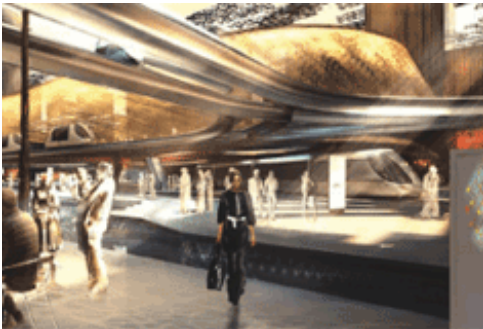


## City of dreams

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By Sian Crampsie



In the heart of the Middle East's oil-rich nations, the tiny Emirate of Abu Dhabi is pinning its economic future on innovative, renewable and low-carbon energy technologies. Sian Crampsie looks at Masdar city, a purpose-built 'ecopolis' designed to showcase the fruits of its investment that is at the heart of this multi-billion dollar initiative.

In 2006, the Emirate of Abu Dhabi announced the creation of the Masdar Initiative, a major programme for the development and commercialisation of renewable and sustainable energy technologies. Just two years later, Masdar broke ground on the world's first zero-carbon, zero-waste, car-free city.

The \$22bn city development is the Masdar Initiative's flagship project, a showcase for advanced, innovative, clean technologies, and a showcase for Abu Dhabi's and the UAE's latest intellectual capabilities and newest economic sector. Masdar City is a blueprint for the future, designed to show that cities can be built and people can live their lives in a truly sustainable way.

While sustainability is at the heart of the initiative, its primary aims are to drive the economic diversification of Abu Dhabi. Masdar is a comprehensive, multi-faceted programme of technology research, development, demonstration and commercialisation. With the financial backing of the government and executed by the Abu Dhabi Future Energy Company (ADFEC), it aims to engage the global energy community to find solutions to climate change, energy security and sustainable development.

The Masdar Initiative is nothing if not ambitious. According to the WWF, the UAE has one of the worst carbon footprints and highest rates of per capita energy use in the world. Yet not only will Masdar city be carbon-free, but will also – in theory – drive the UAE towards greater sustainability and preserve its valuable hydrocarbon reserves. The UAE aims to become an exporter of solar technology within six years.

### Flagship project

Many believe that being truly carbon-free is an unachievable goal, but to silence its critics Masdar is planning to sign its city development up to the WWF's 'One Planet Living' programme – a set of flagship projects that attain certain prescribed standards with respect to sustainability. WWF will independently verify the city's eco-performance, including zero-carbon claims.

Masdar City will be developed in seven phases, beginning with the Masdar Institute of Science and Technology (MIST). The 6km<sup>2</sup> city will grow to house 1,500 businesses and 50,000 residents and is scheduled to be completed by 2016.

The city has been designed by UK architects Foster + Partners, drawing inspiration from traditional Arabic cities with narrow, shaded streets and carefully planned landscape and water features to reduce outdoor temperatures. It will be a walled city that is pedestrian-friendly with a comprehensive public transport system.

The city's design and the use of the most energy efficient techniques available in all areas will drastically reduce energy demand. According to Masdar, the city will require just 200MW of installed capacity as opposed to more than 800MW for a similar-sized 'conventional' city. In addition, the city will be entirely self-sustaining in terms of energy needs.

All of Masdar city's energy supply will be drawn from renewable energy and waste-to-energy technologies. Any excess energy generated will be supplied to the national grid. Initially, the city's electricity generation will come from a combination of photovoltaics (PV), concentrating solar power (CSP) and waste-to-energy.

Widespread use of solar power is an obvious choice for what is essentially a desert city, and Masdar has already made significant inroads into the development of a variety of solar technologies, including one of the largest ever field studies of solar panel technology.

Masdar has invited 22 leading manufacturers of solar photovoltaic (PV) technology to test their products at the Masdar city site. Testing began in late 2007 and the energy produced is being fed into the Emirate's grid. The PV competition will monitor how different technologies endure the hot, humid, sandy conditions, ranking them according to performance. After 18 months of testing, the results will determine which technologies are used to generate energy for Masdar city.

The competition site represents the first grid-connected solar power system in Abu Dhabi and houses 26 1kWp PV modules mounted on aluminium structures. Testing is being carried out in conjunction with TÜV Rheinland of Germany.

## CSP promise

At the same time, Masdar is investing considerably into the development of CSP, one of the most promising solar technologies. CSP plants produce electric power by converting the sun's energy into high-temperature heat using various mirror configurations. The heat is then channelled through a conventional generator.

CSP plants are scalable and versatile with high solar-to-electric conversion efficiencies. They can also be combined with thermal storage technologies or form part of a hybrid system. The technology is of medium maturity and market opportunities in the world's sunbelt regions are considerable.

In March 2008, Masdar signed an agreement with Spanish engineering firm Sener to create a joint venture company – Torresol Energy – to design, build and operate CSP plants around the world. Torresol Energy is aiming to develop 500MW of CSP capacity by 2012, starting with three plants in Spain. Its overall objective is to introduce and test new CSP technologies in order to make it a competitive and reliable technology.

Independently of Torresol, Masdar is currently investigating the potential of CSP in Abu Dhabi with the help of the United Nations Environment Programme (UNEP). In March, the company applied for a licence to generate up to 100MW of solar power using CSP at a site close to the city of Madinat Zayed in a project known as Shams 1. The plant will use parabolic trough technology and is expected to be operational by the end of 2010.

In addition to generating clean electricity from PV technology, Masdar also wants the expertise and ability to manufacture components, and to this end recently signed an agreement with Applied Materials to develop major manufacturing facilities producing the latest generation of thin-film PV modules.

The deal will involve a total investment of \$2bn, and is a significant step in Masdar's objective to transform Abu Dhabi into a developer and exporter of PV technology. The two companies will develop two manufacturing facilities – one in Erfurt, Germany and one in Abu Dhabi – to be operational by Q3 2009 and Q2 2010, respectively. The combined annual production capacity of these two sites will be 210MW, which is committed to major PV system installers in Europe and for Masdar's own energy generation needs.

Masdar is aiming to eventually expand these sites and build new sites, to reach an annual production of 1GW by 2014. Dr Sultan Al Jaber, CEO of Masdar, says: "Thin-film PV is a key part of our build-deploy-develop strategy to actively build a strong position in alternative energy. Abu Dhabi is a global energy leader, so it makes sense to engage these new energy technologies and become a leader in alternatives."

## Waste-to-energy

Another objective of Masdar City is zero-waste through the use of waste reduction measures, re-use, recycling, composting and waste-to-energy. By 2020, 98 per cent of waste from the city will be diverted from landfills, says Masdar.

In June, Masdar announced that it has signed an expression of interest with USA-based EnerTech Environmental for the construction of a demonstration waste-to-energy facility using EnerTech's SlurryCarb technology at Masdar city. The facility will process biosolids (sewage sludge) produced from the permanent buildings erected during Masdar city's first phase as well as from the accommodation for the several thousand workers building Masdar city between 2008 and 2016. The biosolids will be converted into renewable 'E-fuel', a fossil fuel replacement with a heating value of approximately 7,000BTU/lb and used to generate energy.

The proposed demonstration facility is the first step towards installing a permanent SlurryCarb facility in the city.

## Carbon capture

A primary goal of the Masdar Initiative is to drive the creation of a low-carbon economy in Abu Dhabi and the region. Its Carbon Management Unit is spearheading the development of CO<sub>2</sub> emission reduction projects, including the development of carbon capture and storage (CCS) technologies and the creation of a national CCS network for enhanced oil recovery (CCS-EOR).

According to Masdar, a fully-developed CCS network could reduce the UAE's annual CO<sub>2</sub> emissions by 40 per cent while simultaneously increasing oil production by 10 percent. It would also liberate large quantities of natural gas that are currently being used to maintain oil field pressure.

In June 2007, Canadian firm SNC-Lavalin embarked on a major feasibility study to assess and evaluate options for carbon capture and enhanced oil recovery in the Emirate. This groundbreaking study provides a roadmap for the development of a country-wide CCS network recovering carbon from multiple sources and transporting it via pipeline to oilfields. The network could also be connected to similar networks in other countries.

The study also identified the first CCS-EOR project to be developed, a pipeline recovering over 75 million tonnes of carbon per year from sources across the country. It is the very first project of its kind and will be the first in the world to connect multiple industries, including power generation, gas processing and refining, aluminium smelter, steel manufacture and fertiliser and petrochemical installations. Work on the project is due to start this year.

One of the first power projects to be linked into the CCS-EOR network, and one of Masdar's most ambitious projects in its own right, is a 420MW hydrogen power plant being developed in partnership with Hydrogen Energy International (HEI).

The \$2.5bn project will be situated in the Shuweihat area of Abu Dhabi and is scheduled to start commercial operation in 2013, according to Hydrogen Energy, a joint venture between BP and Rio Tinto. Masdar and HEI are about to embark on detailed Front End Engineering and Design (FEED) for the project in parallel obtaining all the necessary permits and completing commercial agreements.

"We have completed the deep feasibility study of the power plant, including an early stage design review, viability assessment and CO<sub>2</sub> assessment and we are about to start on FEED," says David Binnie of Hydrogen Energy. "The project looks very promising and we are ready to move forward with Masdar to the next stage of commitment."

The project will be developed by a joint venture between Masdar and Hydrogen Energy, with the former likely to have a controlling stake. The project partners have already started the equipment supply process, and aims to complete the FEED by mid-2009.

The hydrogen power plant represents the first industrial-scale installation of an integrated hydrogen power plant and carbon capture and storage system. It will take natural gas from the grid and convert it to CO<sub>2</sub> and hydrogen using an amine process. CO<sub>2</sub> will be compressed and exported to the CCS-EOR system, while the hydrogen will be fed into a combined cycle gas turbine power island to generate electricity. Over 1.5 million tonnes/year of CO<sub>2</sub> will be produced for EOR and permanent storage.

“There is no other example of this value chain in the world, although all of its constituent elements are proven at scale,” notes Binnie. “The separation process is proven, the power island is proven and the carbon sequestration is proven, but this plant will be the first of its kind in the world.”

The new power plant will provide more than 5 per cent of all Abu Dhabi's current power generation capacity and the CO<sub>2</sub> emissions reduction will be equivalent to taking all the cars in Abu Dhabi off-the road. “If you take into account the value of the CO<sub>2</sub> in enhanced oil recovery – which could be significant in Abu Dhabi – then we believe that the cost will be very competitive with other forms of low-carbon generation and could be equivalent to conventional generation,” says Binnie.

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