# A Perfect World

*Reflections on Dubai Expo City, 2020 to 2023*

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Press

## Preface

A city is a microcosm, an image of the cosmos.

The first cities, the great Sumerian mud brick cities of Mesopotamia, encircled and surrounded tall temples in their center.

Expo City hosted two great events in its opening years, remarkable years in the midst of pandemic.

Expo set out three great curving paths to its centre, broad pathways from our striving, struggling world to a harmony of nations and nature.

The city hosted the World Expo and a year later COP28, the United Nations conference devoted to saving earth from climate crisis.

*Entering the city*

Approaching Expo from the big parking lots, we arrive at wide concrete pathways leading to the gates. Before the great gates, in the pavement underfoot, are impressed the UN's 17 'sustainability' goals in colorful bands.

We walk over the goals to the tall metal gates, the lovely light metal gates that stand at the three outer entrances of Expo City.

They are tall, tensile, dark rust of color, delicate and light like woven metal fabric. Amazing tall gates, translucent, of the lightest metal mesh, golden in the night time floodlights.

Two great rectangle doors hang open on light hinges. They are light like hanging metal mesh. So we pass through a most marvelous metallic gate to enter the Expo City.

*Coming to the centre*

From the goals to the gate, through the great translucent gate, we come to wide avenues leading to the dome. We enter a special city, avenues of colorful quixotic structures, avenues lined with buildings from every land. These pavilions stand arrayed along the three curving avenues leading to the central dome.

They are capacious avenues, long, gently curving, gradually approaching, revealing the elegant dome, the large round dome looming ever larger as we approach the center.

Domes are man-made symbols of heavenly worlds. They are perfect in shape and dimension. They

contain in symbol the sources of vital life beneath their capacious spheres.

The Wasl Dome is great in dimension, very high, very wide, made of metal tubes and fabric of the lightest desert hue. In the warm Dubai mornings it makes a most marvelous shady space, quiet and calm. At night it becomes a screen of color and light, a giant round screen rising in the dark sky, covered in glowing colors.

It is a theatre of light, everything in nature and imagination appearing, whales in the blue sea, birds floating through the sky, animals, people, fields and forests, all of nature's perfection projected on the dome.

*A perfect world*

From the goals in the concrete, through the golden gates, along the long arcing avenues of nations, we come to the glowing dome.

The symbolism is set out across the vast site, from our striving, struggling world to a perfect world where nations exist in harmony and nature is secured.

At the center is the dome, a perfect form, conveying an enduring balance of man and nature. A balance lasting forever.

Here the World Expo occurred, followed by the big UN conference to solve the climate crisis threatening the world.

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*photo courtesy of Expo City*

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*photo by the author*

World Fairs have showcased great monuments of the modern world: the Crystal Palace, the Eifel Tower, the Ferris Wheel; they have introduced world-changing inventions: the telephone; the television; the touchscreen.

From the sublime to the ridiculous, from great industrial machines to frozen foods, nylons and chewing gum, they show what is now and what is coming. Like our modern world itself, they're quite an oddball collection of things.

The great mix of marvels and technologies on display. The sometimes serene, sometimes idiosyncratic collections of monuments and buildings. The colourful carnival of performers. These convey our achievements, our excellence, our whimsy. A world expo is the world's great expression of itself, just now, at a moment in time. To follow the fairs from London 1851 til now is to follow the many moments of the modern world.

One might call it progress.

But a few thoughtful observers have peered deeper, perceiving in the show something more than the marvels collected there. They have sensed our aspirations. They have perceived deeply the mind of the age.

## I. Centre of the world

Expo 2020 was in the works since 2013, when Bureau International des Expositions awarded the event to Dubai. Delayed a year by the pandemic, it opened October of '21.

They wanted 25 million visits and this they actually achieved, over a six-month run in the midst of a global pandemic. Many were the kind of cultured tourist such an event would be likely to draw. But these alone would not have been enough.

Slashed ticket prices drew in the working denizens of Dubai. In the last few weeks they flooded in. In one weekend Expo drew a million people, heaving crowds of people packed thickly across the enormous site.

Dubai Expo 2020 was the first world exposition to be held in the Middle East. It was the first to be held in that realm of the world that stretches from Africa to Arabia to South and Southeast Asia; the most peopled, rapidly growing realm of the world, where the greater part of the world's population growth now occurs.

It is a sunny, warm world encircling the warm waters of the Indian ocean. And Dubai sits at the centre of it.

*A great arc of growth*

New cities must be built, new technologies must become widespread, new industries must arise in this burgeoning realm of the world, this great arc of growth. To sate the soaring desires of these young populations is the great work of our century.

And at the centre of this arc lay the cosmopolis called Dubai, which, being at the centre, is a fitting place for this world's fair.

Dubai sought to say something about this burgeoning realm. It tried, at least obliquely, to approach an answer. It approached an answer to the fundamental problem we face, the problem of saving our planet while sustaining our hectic high-growth way of life.

So it said something about energy. It said something, unwittingly and despite itself, about our hoped-for energy transition in the midst of our clamour for growth. It struggled and did not fully succeed in its attempt to address the great challenge of our age.

*A mirror that shows the future*

World expositions produce an ideal world of harmony, a peaceful gathering of nations. Such was the wish of Prince Albert at the opening of his world exposition, the first, in London in the Crystal Palace in 1851.

He thought the great exposition held great promise for the future; in the gathering of arts and industries on display. Thoughtful observers since then have gained glimpses of the future in the Expo's eclectic collections of things.

In 1893, Henry Adams marvelled at the dynamos and great machines on display in Chicago in the Manufactures Building. He remarked on the enormous power and quantities of energy they require. There, in the Chicago exposition of 1893, he saw in outline the coming 20th Century. He saw mass scale, huge industrial organizations, great labour unions, these powers coming to dominate the republic's political life, and the inevitable rise of a welfare state to assuage the masses.

The enormous power of the machines would require massive organization to manage it. But his ponderings did not extend to nature or what we would call 'the environment'.

That mass scale America had emerged by 1939 when the World's Fair opened in New York. The

monumental Trylon and Perisphere were its centre. But the General Motors pavilion was a 'Futurama' model of an auto nation, of highways and suburban sprawl. It is a world that came to be, after the War, in the second half of the twentieth century.

This enthusiasm for cars and sprawling suburbia continued. Again in New York, in 1964, the auto and its liberating mobility for the masses was celebrated. In Osaka, in 1970, the famous Saudi Pavilion showed a great gusher of oil amidst displays of the Kingdom's arts and industries built upon its newfound oil wealth.

The idea of environmental sustainability was absent or simply assumed. But it gradually crept in. The Montreal Expo '67 took the theme 'Man and His World'; its Habitat 67 was a build-up of apartments and gardens in seeming balance. It was an answer to an urbanizing world, a future already unfolding.

*Nature in balance*

Dubai Expo 2020 did not simply celebrate industrial progress, as Expo has going back to Prince Albert's day. Dubai revealed a longing for rebalancing, for a new start of civilization in carbon-free energy systems.

In Dubai nature gained equality with industry, as shown in its art, its technology, its overriding concern for sustainability. It said in obvious and subtle ways that we face critical questions of life on the planet.

Such was the message of this Expo – however far from the actual world of the early 2020s it was.

Dubai showed all the ambiguity of our current moment. It said much about our real condition, even in spite of itself. Its organizers promised to make

the ‘most sustainable’ Expo in the history of expos. This they may have achieved, although Expo City’s operations fell far short of net-0.

Its shortcomings showed how far we are to a sustainable, post-carbon future. Quite far. Meanwhile the swirling events of the early 2020s belied its hopes for a harmonious world; indeed, during the very moment of the fair a sovereign country was invaded. Globalization’s breakdown loomed.

*A thoughtful thing*

World Fairs lack the drama of the Olympics. But they carry more intellectual interest. They’re thought-provoking, something of a museum experience, but much more fun. They’ve engaged the minds of a few great thinkers.

In Chicago, in 1893, Henry Adams saw the industrial dynamos on display in the gleaming beaux-arts White City on the shore of Lake Michigan. What was the meaning of the thing, so classical, so symmetrical, so unified and well planned, so strange and out of place yet somehow there, in the middle of America? He sat below Richard Hunt’s high muraled dome and pondered. He thought it meant quite a lot, if not sure what.

His musings did not extend to human impacts on nature or the natural world. In fact they were deeper.

A quarter century later in his ponderous autobiography he wrote, “… Chicago was the first expression of American thought as a unity; one must start there.”

That’s a weighty statement from a thinker qualified to make such statements. What reflections might Dubai’s

Expo provoke, among serious thinkers, right there in the warm muggy air, on the saltwater shores of the Arabian Gulf?

Dubai's Expo was an organized jumble of things, a clutter of pavilions, a cavalcade of shows and spectacles. It was all rather silly and fun. But for those who peer through the colorful clutter, to the actual substance, fascinating insights await.

*A quixotic collection*

The Dubai Expo city is a giant flower, three long petals attached to the flower's center, the round Al Wasl dome. They demark three districts anchored by three main pavilions.

The huge dome is alight in vivid colors, like Richard Hunt's lost murals of an earlier age. Now electric colors stream on the silvery dome, rich purples and reds at night. An open stage spreads across the capacious platform below. Performers, small in the space, sync with enormous laser lights on the dome high above, producing remarkable shows.

The three petals lead to the centre or extend from the centre. Their edges are long, broad avenues, gently curving into the three main pavilions. Beyond these, in the petals' tips, stand the three great entry portals, the tall tensile metal portals with delicate open doors, enormous, lovely, almost floating. Serene in daytime, at night they soak in resplendent yellow light.

It's quite enormous. In daylight it's all quite tranquil. The dome's vast, softly shaded space fills with Dubai's muggy morning air. A gigantic sound system emits deep soothing hums. The calmness carries out along the broad walkways that carry the crowds; fabric

canopies spread above them making soft shade.

The curving Ghaf avenue bisects the diagonals, named for its Ghaf trees although the thin green trees appear lost in the visual clutter.

These long avenues host a quixotic collection of forms, the pavilions of the countries, whimsical buildings built by the contributing countries.

It is all a delight from the 'floating garden,' the round rising platform with potted trees, which goes up and down giving good views all around.

The marvelous collection is bizarre in the daylight and aglow in colorful light at night.

Each pavilion reflected its country in different ways, literally or symbolically, each in some way saying, 'you know who this is.'

Some conveyed its nature, like the tall pine columns of Sweden, the towering tropical garden of Singapore.

Some conveyed more its historical essence, seen in the colorful temple forms of Thailand (with two cute dolls in front), in the rich golden drapes of Persia.

Some conveyed its essence in its ancient collaboration with natural gifts, as the Frankincense bowl of Oman (actually an ideal Frankincense tree), the sleek metallic falcon of the UAE.

Others were purely symbolic, as the soft white paper forms of Japan, the brown stone blocks of Egypt.

A few were literal, like the metallic silver stars of the USA – with space rocket in back (we are a literal people).

The large, bulky shape of the Kuwait pavilion conveyed its desert directly on a massive video screen wall where a big, calm camel went casually striding by.

Others conveyed in abstruse symbol their historical adventure, as the swollen plastic pistachio green roof of Italy, its walls of ropes symbolizing sea voyage, all made of recycled stuff.

Others seemed idiosyncratic, seemingly pure whimsey, purpose made for this show, like the leaning mirror-faced cube of Saudi Arabia, the multitudinous lighted squares of Korea, the bellows of the UK, the bright wrapping rubber bands of Russia in white light, the Lego-block shape of 'Campus Germany', the amazingly oversized building of little Luxembourg.

Some showed some specific environmental intent, like the clay cones of Austria, the curving green wall of Slovenia. Others conveyed a more subtle environmental intent, in the rusty metal face of the Netherlands, the stainless steel capillaries of Czech Republic.

Pakistan, Nigeria, Angola, Turkmenistan, Brazil, Belgium, France, Poland, Hungary, and many other unique pavilions lined the long avenues, one after another, all offering interesting displays and some tasty food inside. The restaurants in Hungary and Slovakia were pricey and excellent, the beer garden in Belgium was great. The 'stan' countries' ancient forms and flavorful foods also impressed.

Within the petals are the shady passages, the *sikka* where much of the city is. Here are the Expo-built buildings of prefab concrete walls, rectangles of good size. They contained the exhibit rooms of two or three

countries. Amidst them are the shady sikka with wispy ghaf trees and the tall metallic shading structures – funnel-shaped metallic trees allowing dappled light. Nicely set amidst them are small parks and stages.

Here is a city, a delightful fantasy city of 192 countries each with its own space, a record for Expo events.

## II Seeing sustainability

Planners set out ambitious goals for energy, water, and waste, established targets and performance indicators, and put protocols in place for monitoring and reporting. Their efforts showed significant fruit after seven years of planning and construction.

More than 110 of Expo's buildings (about 80% of its buildings) received the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) Gold certification, which requires their permanence. Seven of the signature pavilions, including the architecturally stunning contributions of Saudi Arabia and the UAE, received the vaunted LEED Platinum rating.

A record 192 countries participated, each with its own pavilion. Most were housed in Expo-built buildings, but many countries built their own signature structures. They were required to submit detailed plans for construction, operation and eventual dismantling, ensuring their adherence to high environmental standards for materials, energy, water, and recycling. Specific requirements were set out in each of these areas; for example, Expo required that all wood used on site be procured according to special sustainable materials guidelines.

Solar panels placed on the roofs of all permanent buildings (Expo-built buildings) created enough power to meet about 30% of their energy requirements – a respectable figure for rooftop solar. For water, all buildings were required to be 50% more efficient than Dubai's baseline in water consumption, requiring careful planning for water capture and reuse, even banal things like low-flush toilets.

Digital tech has an inevitable role in future sustainability. The MindSphere Smart City system of the Siemens company deployed more than 200,000 sensor points across the site to monitor key indicators of energy and water.

*Planning, learning, adjusting*

Expo stated its intention to engage in constant planning, measuring, learning, and adjusting (planners carefully documented Expo's outcomes in three reports).

In 2013, when the award was announced by BIE, the Expo leadership committed to make Dubai's the most environmentally sustainable in the whole history of these events.

The thinking was quite whole-life or circular. The national pavilions were to submit plans for their construction, operation, dismantling, according to high standards for materials sourcing and reuse. The Expo-built pavilions were to achieve LEED Gold certification with solar panels on all the roofs.

As noted, Expo achieved about 30% of electricity for the Expo-built buildings from their rooftop solar panels. It was replacement energy going into Dubai's electrical grid. Meanwhile, water conservation

requirements resulted in some significant water savings.

Special materials and building practices presaged the future. They may well become widespread in the rapid build-up of cities through the great arc of growth.

Modular construction was in evidence everywhere. Walls, floors, windows were premade in standard dimensions for on-site assembly. The Expo-built buildings, which were a great proportion of what was built, were entirely prefab with rooftop solar. The national pavilions had much prefabricated interior content within their flamboyant exterior forms.

The Expo site before it's building was barren desert. Interestingly, for an exposition in a desert, wood was prominent across the site in many of the national pavilions.

A most basic thing of nature, beautiful wood, wood from trees that gather up carbon and regrow from fallen seeds after they're cut down, to gather carbon again, was prominent.

Wood is the good surface carbon that served man for millennia. Some say we can tackle a big chunk of climate change by simply planting a trillion trees. And wood may prove to be an important element in future carbon-free cities.

The Swedish pavilion deployed 300 tall pine trees, 40-60 years old pine trees from Sweden, a forest of awesome columns upholding the high wooden roof. On display within, amongst many wonderful things, was a wooden brick, a beautiful dense thing composed in a manner called CLT – cross-laminated timber – which

may become very important for future cities.

The assiduous Swedes planted 720 trees for the 300 removed, so more than 2 per one removed. They had on display pulp fibres for clothing, to waste nothing.

The building is all wood, a foundation of wood, a wooden basement sunk in the sand, so they claimed theirs is the first all wood building in Arabia. The Polish pavilion was also all wood, although the Swedes claimed theirs was finished first.

The Polish pavilion featured Siberian lodge and ash. During Expo it hosted a succession of shows of regions of Poland, for example Silesia, showing forests and shining cities, folk dancers, industries and crafts.

Hungary featured a bukk forest, wood of the bukk tree, and the magnificent hydrology of the porous stone beneath its steppe. Finland, made of pine, had the most amazing room of the Expo, the Gorge Oasis, a crevice leading into a high sky-lit room of swooping wooden walls, modelled on the Chapel of Silence in Helsinki.

Actually, the young people attending these pavilions were not sure if all these woods in the structures were actually authentic woods of their countries. Perhaps much of it was dressed up commercial wood, presumably sustainable. At least the intention was evident.

Malaysia showed the medium-hard merantti wood of its forests in the structure. The building had sort of a jungle feel with planted trees in front, which had been brought from Malaysia and planted there.

Oman was a Frankincense tree of the Wadi Daukin. It

showed the rich resin. And the flows of sustainability in the Dhofar wind power plant.

So the woods of all these places could well become the basic materials of future cities, of whole buildings built of them, while the forests regrow to capture the lost carbon again. Perhaps even in the Middle East imported wood could work.

And the possibilities of prefabrication were also elegantly on display.

Behind the little pavilion of the Dubai Energy and Water Authority was the Future Haus designed by students of Virginia Tech. Everything is rectangular, clean, glossy bright white, with ingenious space saving. An office that becomes a bedroom, or a dining room, according to the need of the hour of the day.

It is composed of 12 ‘cartridges’ for simple and fast assembly. The idea is to build homes like building cars. The students were working on ‘energy positive’ production; sounds nice.

*Seeing Future Energy*

The Dubai Energy and Water Authority (DEWA), a very big utility company, had just a little building, small but prescient of the future.

The scale of photovoltaics relative to need – adding up the wattage to power the world by the sun – was on display in DEWA.

DEWA’s MBR solar park is among the largest in the world (together with its enormous sisters in neighbouring desert of Abu Dhabi emirate). More than 1GW of solar power was providing 9% of Dubai’s energy, planned to rise to 25% in 2030 when the

sprawling solar plant will reach capacity of 5GW.

Phase 1 was completed in 2013, 13MW of photovoltaics. Phase 2 in 2017 added 200MW pv, Phase 3 in 2020 added 250MW pv and 700MW concentrated solar power in a magnificent array, an amazing glow candle of concentrated sunlight standing in the desert. Seen far off in the desert, it matches any dream of future energy in a sci-fi writer's imagination.

Phase 4 under construction was to add 950MW. From all the info in the DEWA pavilion one got a good sense of what Dubai is trying to do, and can roughly add it up, to get a sense of how much sunlight will need to be captured to actually power the city. It's quite a lot.

They will need about four more MBR solar parks sprawling out in the desert by 2050, in addition to their nuclear power, and their natural gas with carbon capture.

This is for all of Dubai. But the other key part of the energy transition is not what you have but what you don't need. The conservation question is kind of the boring side of it, (like, 'oh yeah, energy conservation, good idea…' yawn…) but it can be beautiful.

So besides its massive utility-scale solar park for a city, DEWA also displayed what can be done micro-scale with a building, namely its 'zero energy' headquarters Al Sherra building then in planning. It's a building of 2 million square feet, 1000 square meters of photovoltaics, producing 6500 MwH per year.

The energy of the sun and wind can produce a lot of power, but there is a lot that  electricity cannot do on the more energy-intense end of the economy. So

also on display, and perhaps greatly prescient for the future, was the hydrogen pilot project at the MBR solar site. It connects sunlight to water to isolate the tiny, energy packed molecule that burns carbon-free.

Hydrogen packs the density of energy that we'll lose when we relinquish fossil fuels. The pilot project is making a tiny amount for research but it is a great hope of the day, as governments dream of making hundreds of thousands of tons of hydrogen with the desert sun to export to Europe, China, Korea, Japan. It is still very much a dream, one that may never get to market scale, but gathering great momentum in 2022.

Interestingly, there was not much on robotics, except for the cute little robots scooting about with video faces smiling making 'uh-ha' sounds, to the great delight of children. If these guys are the future of robots then we have nothing to worry about.

Expo also just missed the commercial chatbot AI explosion, which happened suddenly in late '22. The next expo in Osaka will likely put more focus on these tech topics.

*A little imagination*

So, with a little imagination, one begins to see a city that, amazingly, doesn't need the fossil energies that we have so long needed for their irreplaceable density of energy.

A city where they are replaced, that runs almost carbon-free, what does it look like?

Maybe a little like this Expo.

It looks like vast areas of prefab buildings, blocks or boxes with solar panels atop. A few buildings have

special shapes, in special places throughout the city, as in our cities now, but these cleverly designed to capture every ray of light and burst of wind and drop of water, beautiful bright things like DEWA's new building.

All this made in hydrogen-powered factories for simple and fast assembly; pre-fabrication and modularity are prevalent.

If net-0 is a moving target, it requires a constant process of planning, learning, and adjusting. The future city's key indicators must be monitored by IT systems for constant adjustment and improvement.

Imagine high-tech, pre-fab cities for the masses surrounded by great solar parks in earth's great sun-drenched arc of growth.

It's all there in Expo City in disparate pieces: the wood, the solar power, the hydrogen, the modular construction, the tech. You just need to put it all together in your imagination.

Of course it cannot be built on mass scale cheaply; the economics remain daunting.

Some years ago a friend of mine, a scientist in retirement after many years in energy research, gave me his summation of the matter. "There's just no cheaper way to get energy than digging a hole in the ground," he said.

That was some years ago. The cost of solar power is now well lower than coal. The economics of it are changing quickly. Expo may indeed have shown us much that will be in the future.

## III Through mystical gates

Coming through the mystical metallic gates, one enters the tips of the petals. It was in one these, one area around the sustainability pavilion, where Expo may have been most prescient, most insightful of the future. In this area the sustainability pavilion and three smaller country pavilions stood in proximity.

If Dubai's Expo had anything lasting to say about the future, it was likely here, in this small section of the sprawling city.

Here were technologies and methods boldly addressing pressing problems, particularly of energy and water. The close connection of these critical pieces of sustainability - energy and water - appeared in a fascinating progression of ideas; ideas that may well emerge to serve the world's burgeoning cities.

### *Terra the earth pavilion*

Terra – the Earth Pavilion anchoring Expo's Sustainability District – presented a basic idea to build on. It would achieve a complete system, producing energy and water equal to what it consumes.

Never was solar power more dramatic. The great photovoltaic canopy hovers above the building on a 30-degree slant. The elegant, elongated oval, 130 meters in length through its middle, holds 1055 solar panels in 2000 tons of steel. Its glass panels laden with ultra efficient photovoltaic cells flow gracefully into a hurricane-eye that sinks to a courtyard below, expelling heat as a chimney.

The canopy's angle, carefully set to maximize breeze,

combines with the semi-transparent solar panels to create a lovely shaded courtyard, a space 1-2 degrees C cooler than the surrounding air.

More delightful shade lay below the forest of 18 ‘energy trees’ surrounding Terra; trees that resemble in metal the desert trees of Yemen’s Socotra Island. Their solar panels, embedded in strong but light weight carbon fibre, are bi-facial, tracking the course of the sun through the day while picking up reflected light from the ground (the reflected solar rays add 20% efficiency).

The great canopy and the trees generate 4GwH electricity per year, in a continual flow of power that rises with the daylight and ebbs at night. There are no batteries to store it; excess daylight power flows to Dubai’s utility grid, which returns the power at night. But the intention is to balance through the days and the year.

The sun powers Terra’s rooms, restaurants, and large exhibit spaces that exist below ground to evade summer’s harsh heat.

The sunlight also powers water production. The building consumes large quantities per day, most of it from its own recycling and water production.

The great solar canopy collects rain and dew. A sponge-like technology sucks up water from the A/C units. And amidst the forest of energy trees is one solar-powered water tree, shaped as an upward cone to directly harvest water from the air through a cactus-like reverse transpiration process. This tree is for demonstration but it does contribute.

The whole site shades the building and holds water. The landscape of regional natives and adaptive species, baobab trees, and succulents, needs about 75% less water compared to the regional norm. The site receives the wastewater of Terra for irrigation and natural cleansing. In one innovation, grey water goes through transparent tubing atop the solar canopy, letting the sun's rays directly kill its bacteria.

Every part of Terra's construction is thought through. Instead of concrete (concrete production is intensely carbon emitting), its walls are composed of gambion rocks – a system of cages containing rocks – locally quaried in the Hatta mountains. An aggregate of recycled material forms the floors, while stairs are composed of concrete poured over hard, hollow shell 'balloons', gaining all the strength of concrete with much less material.

Terra actually learns and adjusts. Much more than a 'smart building,' it gathers data from numerous sensors that are integrated with Siemens' MindSphere monitoring system across the Expo site. The powerful platform monitors its energy and water consumption, its interior and exterior climate, its waste production, allowing managers to tweak and meet goals.

The building's intention – to achieve net-0 energy and water – is to be continually assessed and adjusted. According to Expo, it is to become a children's science museum and centre for study of sustainable development.

*Three pavilions*

Terra's idea, complete sustainability, took on unique forms in three neighbouring pavilions. Like all of the 192 country pavilions across the huge Expo site, they kept busy hosting exhibitors, commercial and cultural events from their countries. But they made this corner of Expo particularly interesting with their display of related ways to deploy and direct nature's power, in carefully designed systems at once beautifully simple and sophisticated.

They advanced the idea of making water for a drought-ridden planet facing climate change. To the ancient idea of atmospheric water generation – grabbing the humidity in the air – they added high-tech materials and machines powered by the sun.

These were joined to more key ideas for sustainable city building. Modularity, with a standardization of materials to allow quick construction, dismantling and reuse, appeared as something required for mass scale construction. The idea of recycling and reusing everything from floor to roof was prevalent.

Across the way from Terra was Slovenia, where renewable wood (spruce) and a green wall wrapped around the elegant little egg-shaped building. The 45,000 plants in the wall conserved water and kept the building cool. Embedded in a natural material of volcanic stone, which greatly slowed evaporation even in summer, the green wall supported birds, butterflies, even snakes, with 16 moisture sensors that guided constant adjustment of water flow.

The building was composed largely of pre-fab

components. The green wall came in pre-seeded, one-meter square panels that could be quickly assembled. Its producer, Slovenia's Urbanscape company (the designer of the green roof garden on the new Dubai Opera), intends these for wide use in the Middle East.

Its undying greenness through Dubai's summer heat amazed observers. It was thriving even in June, in 55-degree C heat; very few of the panels required replacement.

The nearby Czech Pavilion shared much the same concerns but solutions took on a harder industrial edge. The fantastic swirl of stainless-steel tubes adorning its façade represented water-carrying capillaries serving the system within.

That system, called SAWER (solar-air-water-earth-resources), linked machines producing water from the air for drinking and for irrigation. Displayed behind a long glass wall on the building's man floor, the SAWER forced a high-speed stream of air through a 'desiccant unit' whose special silica surface captured molecules of water. This more concentrated stream of air was heated and again forced through the desiccant, producing hot wet air from which condensation was captured.

Designed by researchers associated with the Czech Technical University, it could make 900 litres of water per day and cold air for the A/C. Powered by special 'hybrid' solar panels on the roof that produce both electricity and heat, its water went to one machine to be remineralized for drinking. But most went through a photo-bioreactor that added nutrients and symbiotic

fungi, preparing richly green water going to irrigate the surrounding landscape in an undersurface irrigation. The green water's fungi attach to the roots of plants to hold nutrients and limit evaporation.

So the water production was directly related to the solar power. One to two litres of water was produced per square meter of solar collector surface, per day, depending on the season.

Again, the system is modular, scalable, portable. Its inventors say that it can be produced in standard-size units that will function autonomously in desert environments. It won't replace desalination for big cities like Dubai, but it could serve more rural and isolated areas throughout the world that lack dependable water supplies.

The tendencies in the Slovenian and Czech pavilions reached a high art in the neighbouring Netherlands.

The Dutch Pavilion composed sustainability in multiple interacting dimensions, where solar energy, manufactured water, green walls, recycling and modular construction reached true circularity, where they combined to produce actual food.

Some 95% of the pavilion was built using recycled material. Steel sheets and pipes were rented locally. The building, designed by V8 Architects, housed a temporary 'biotope' in a circular climate system, in the centre of which was a giant green cone covered in edible plants that were irrigated with captured water.

Pavilion visitors, provided with umbrellas, were treated to a lovely light show within this huge plant-covered metal cone. The show finished with a stream of

water pouring down from the roof.

The building created a circular water system from basement to roof, with rooftop solar panels powering a dehumidification unit on the roof. This unit, the 'SunGlacier' designed by inventor Ap Verheggen, captures water in a unique, rather ingenious way.

Verheggen describes it as 'blowing air in a cold shower' to create a 'growing waterfall'. The humidity in the warm air condenses against the cold water drops, growing those drops, creating a waterfall that grows in volume while falling down.

This solar-powered rain shower produced up to 2,000 litres per day, enough to water the green cone. The system cooled the building while watering the plants. Special transparent solar panels allowed sunlight to filter into the enclosed metal room. The humidified air, rich in CO2, provided a perfect climate to grow a great variety of things, even tomatoes. A 'bar' on the second floor served the water from taps, clear, cool and delicious.

The SunGlacier, and the whole building, was built to be temporary, portable, scalable, mass produced. Verheggen continues to develop the technology, now applying it to large greenhouses.

He believes it can work in large-scale urban applications, not replacing but supplementing other systems to serve burgeoning populations in the world's expanding drought-prone areas.

Again, it won't replace the huge amounts of water produced by desalination for huge cities, but desalinated water for households could be mixed with

fresh SunGlacier water to fulfil everybody's needs.

Verheggen thinks it could lead to a significant reduction of the negative effects of desalination.

## IV A perfect world

*A new Dubai*

A big piece of infrastructure, giving a lot of credibility to Expo's sustainability drive, was the 9-mile Metro extension to the site. About a quarter of the 25 million visitors to Expo arrived by metro, a remarkable feat for Dubai.

Some 80% of the Expo-built buildings within the petals were to remain to form the nucleus of a new city-district. Among the idiosyncratic country-built buildings along the petals, many would come down, a few would remain, some countries entering agreements with the Expo leadership to remain for another few years.

There was to be a build up over the parking lots surrounding the flower, to make an enormous new net-0 city district. Planners foresaw putting all car parking below, in the tunnels built to service the pavilions during Expo. So the city would remain a walking city long after Expo's crowds had gone.

This will be a new Dubai, a '15-minute' city in the current lingo of planners.

*Energy ambivalence*

In Dubai's Expo there appeared a great yearning to hold human growth in a new balance with nature, to wed technology to natural forces. This yearning

achieved perhaps its most eloquent expression in the part of Expo centred on the magnificent Terra Pavilion.

Expo's considerable success showed a serious effort by Dubai, a city widely considered one of the world's least sustainable but now advancing a Clean Energy Strategy to have 75 percent of its energy from non-carbon sources by 2050.

Expo was really something of a pilot project. It fell far short of net-0 but showed diverse systems and technologies coming into place for a hoped-for carbon-free future.

The ambivalence of our current moment was on display at the energy company pavillions at Expo.

A remarkable example was the 'Malaysia Net-Zero Carbon' pavilion, with beautiful displays of a country that is called 'megadiverse' and a 'carbon-sink' (53% is forest). An amazing, gigantic lighted cube displayed the Petronas net-zero by 2050 objectives. It praised natural gas, future hydrogen, and a circular economy for plastics.

*Contrasting stories*

During the latter days of Expo in early '22 the Atlantic Council hosted an annual energy conference in the new Dubai Exhibition Centre, an enormous twin-building complex on the edge of Expo City by the metro station.

A lot of discussion of the difficulties of the energy transition ensued. At one discussion, US oil company execs discussed their companies' low-carbon initiatives. They all looked rather bored with it. One exec, head of a Texas-based company, told the story of his recent trip to Peru where he saw mountain villagers

taking their produce to market in a pick-up truck. The truck, he said, was necessary for their livelihood and necessarily run on petrol, because, as he said, these poor villagers "won't be driving Teslas anytime soon."

With thought leadership like this, it's clear that the energy transition will not be led by the petroleum sector. His comments contrasted with the story told in the Opportunity Pavilion, where the sun mama gives sustainable energy that transforms rural communities.

This ambivalence, the contrast of our current reality under the weight of the petrol economy and a hoped-for carbon-free future, was redolent throughout Expo. It found expression in the displays of the Emirates National Oil Company (ENOC), which placed a 'service station of the future' on a nearby road outside the Expo gates. The little solar powered service station (needs just a few solar panels) offered a small bank of EV chargers and two rows of petrol pumps.

*Still striving*

After a few days roaming the colourful confines, the great symbolism of it becomes apparent.

Dubai Expo showed us a perfect world inside the mystical gates, at its centre a beautiful balance of man and nature. Around this centre spread the nations in harmony, each contributing gifts to achieve the sustainable balance.

Leading up to the gates, impressed in the pavement, lay the UN's 17 sustainability goals underfoot. That's where we are now, still striving.

*COP28*

Some 18 months after Expo closed, the UN climate conference COP28 opened at Expo City. A 'blue zone' for diplomats held place in the same Dubai Exhibition Centre. A 'green zone' for the public spread over the Expo site. An impressive list of world leaders appeared in the first days, offering short but sometimes impassioned speeches. Then the diplomats got to work under the guidance of a respected Emirati oil exec.

On the final day of the UN conclave, after two long weeks, they arrived at a 'UAE Consensus' calling for a phase out of fossil fuels, remarkably for the first time in the many years of UN climate talks. Significant strides were made in frameworks, new fuels and technologies. Significant funds were committed by some governments. But many saw the heavy hand of fossil fuel industries in the UN process and despaired of its ability to compel sustained urgency to reach net-0.

The setting of COP28, on the sprawling grounds of Expo City, conveyed all the hope and concern of that moment in time, in December '23. The great vision and limited strides of the conclave matched the great vision and partial success of the city. So the setting was appropriate to the result: the outlines of a future post-carbon world began to appear, just barely appear, upon a distant horizon.

So now we can see it; we almost know how to get there.

Can we reach it?

Expo City's perfect world harbors hope.


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