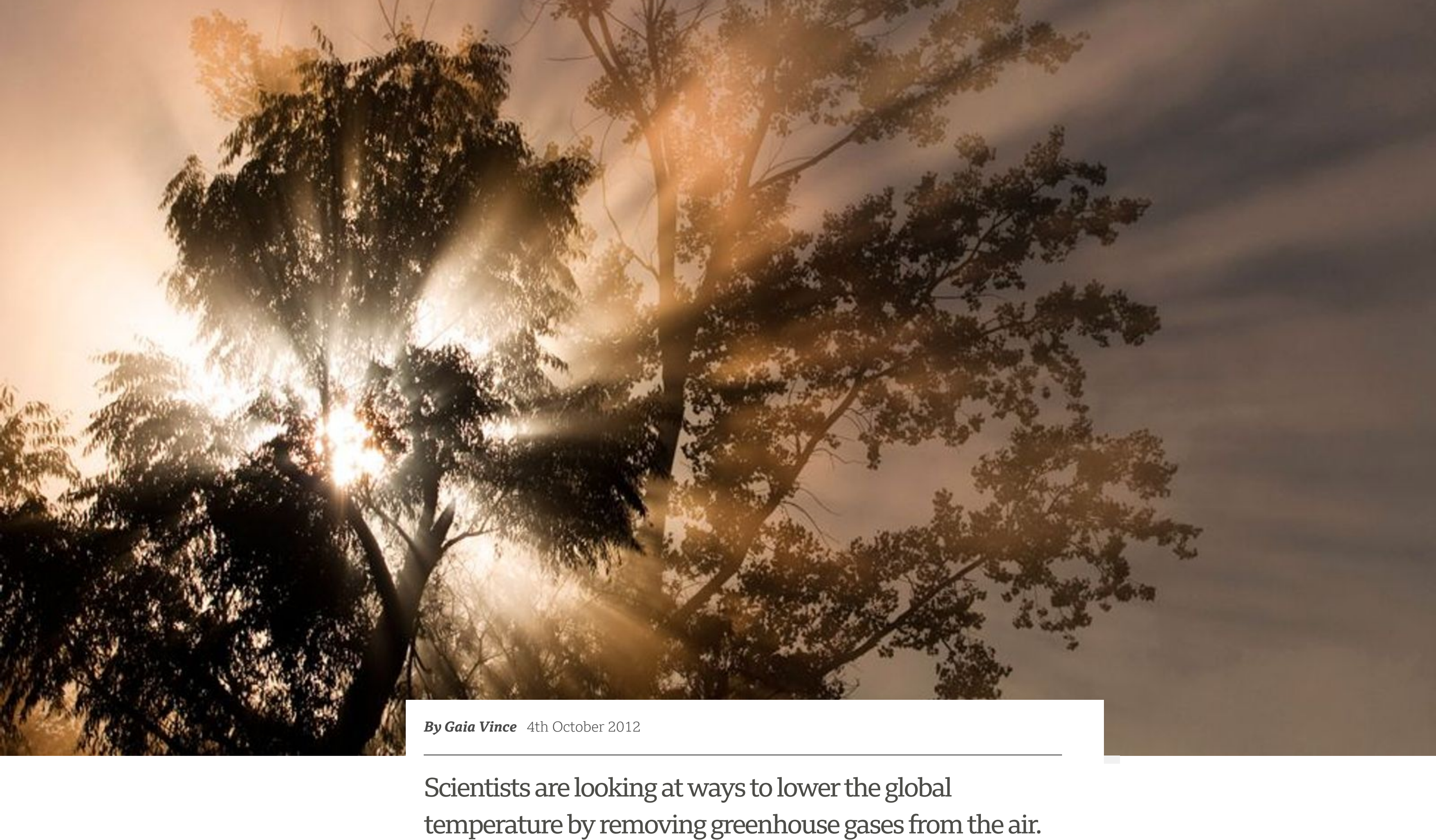


Sucking CO2 from the skies with artificial trees



(Image credit: Science Photo Library)



Scientists are looking at ways to lower the global temperature by removing greenhouse gases from the air. Could super-absorbent fake leaves be the answer?

It may be a colourless, odourless and completely natural gas, but carbon dioxide is beginning to cause us a lot of problems. It only makes up a tiny fraction of the atmosphere (0.04% of all the gas by volume – or 395 parts per million) but it has a huge effect on the Earth's temperature. That's because unlike nitrogen or oxygen, carbon dioxide molecules absorb the Sun's heat rays even though they let light rays pass through, like a greenhouse.

Scientists are looking at ways to modulate the global temperature by removing some of this greenhouse gas from the air. If it works, it would be one of the few ways of geoengineering the planet with multiple benefits, beyond simply cooling the atmosphere.

Every time we breathe out, we emit carbon dioxide just like all other metabolic life forms. Meanwhile, photosynthetic organisms like plants and algae take in carbon dioxide and emit oxygen. This balance has kept the planet at a comfortably warm average temperature of 14C (57F), compared with a chilly -18C (0F) if there were **no carbon dioxide in the atmosphere**.

In the **Anthropocene** (the Age of Man), we have shifted this balance by releasing more carbon dioxide than plants can absorb. Since the industrial revolution, humans have been burning increasing amounts of fossil fuels, releasing stored carbon from millions of years ago. Eventually the atmosphere will reach a new balance at a hotter temperature as a result of the additional carbon dioxide, but getting there is going to be difficult.

The carbon dioxide we are releasing is changing the climate, the wind and precipitation patterns, acidifying the oceans, warming the habitats for plants and animals, melting glaciers and ice sheets, increasing the frequency of wildfires and raising sea levels. And we are doing this at such a rapid pace that animals and plants may not have time to evolve to the new conditions. Humans won't have to rely on evolution, but we will have to spend hundreds of billions of dollars on adapting or moving our cities and other infrastructure, and finding ways to grow our food crops under these unfamiliar conditions.

Even if we stopped burning fossil fuels today, there is enough carbon dioxide in the atmosphere - and it is such **a persistent, lasting gas** – that temperatures will continue to rise for a few hundred years. We won't stop emitting carbon dioxide today, of course, and it is now very likely that within the lifetime of people born today we will increase the temperature of the planet **by at least 3C more** than the average temperature before the industrial revolution.

Seek and capture

Hence, the idea of finding ways of removing carbon dioxide from the atmosphere. One way to do this is to grow plants that absorb a lot of carbon dioxide and store it. But although we can certainly improve tree-planting, we also need **land to grow food** for an **increasing global population**, so there's a limit to how much forestry we can fit on the planet.

In recent years there have been attempts to remove the carbon dioxide from its source in power plants. **Scrubber devices** have been fitted to the chimneys in different pilot projects around the world so that the greenhouse gas produced during fossil fuel burning can be removed from the exhaust emissions. The carbon dioxide can then be cooled and pumped for storage in deep underground rock chambers, for example, replacing the fluid in saline aquifers. Another storage option is to use the collected gas to replace crude oil deposits, helping drilling companies to pump out oil from hard to reach places, in a process known as advanced oil recovery.

Removing this pollution from power plants – called **carbon capture and storage** – is a useful way of preventing additional carbon dioxide from entering the atmosphere as we continue to burn fossil fuels. But what about the gas that is already out there?

The problem with removing carbon dioxide from the atmosphere is that it's present at such a low concentration. In a power plant chimney, for instance, carbon dioxide is present at concentrations of 4-12% within a relatively small amount of exhaust air. Removing the gas takes a lot of energy, so it is expensive, but it's feasible. To extract the 0.04% of carbon dioxide in the atmosphere would require enormous volumes of air to be processed. As a result, most scientists have balked at the idea.

Fake plastic trees

Klaus Lackner, director of the Lenfest Center for Sustainable Energy at Columbia University, has come up with a technique that he thinks could solve the problem. Lackner has designed an artificial tree that passively soaks up carbon dioxide from the air using "leaves" that are 1,000 times more efficient than true leaves that use photosynthesis.

"We don't need to expose the leaves to sunlight for photosynthesis like a real tree does," Lackner explains. "So our leaves can be much more closely spaced and overlapped – even configured in a honeycomb formation to make them more efficient."

The leaves look like sheets of papery plastic and are coated in a resin that contains sodium carbonate, which pulls carbon dioxide out of the air and stores it as a bicarbonate (baking soda) on the leaf. To remove the carbon dioxide, the leaves are rinsed in water vapour and can dry naturally in the wind, soaking up more carbon dioxide.

Lackner calculates that his tree can remove one tonne of carbon dioxide a day. Ten million of these trees could remove 3.6 billion tonnes of carbon dioxide a year – equivalent to about 10% of our global annual carbon dioxide emissions. "Our total emissions could be removed with 100 million trees," he says, "whereas we would need 1,000 times that in real trees to have the same effect."

If the trees were mass produced they would each initially cost around \$20,000 (then falling as production takes over), just below the price of the average family car in the United States, he says, pointing out that 70 million cars are produced each year. And each would fit on a truck to be positioned at sites around the world. "The great thing about the atmosphere is it's a good mixer, so carbon dioxide produced in an American city can be removed in Oman," he says.

Social cost

The carbon dioxide from the process can be cooled and stored; however, many scientists are concerned that even if we did remove all our carbon dioxide, there isn't enough space to store it securely in saline aquifers or oil wells. But geologists are coming up with alternatives. For example, peridotite, which is a mixture of serpentine and olivine rock, is a **great sucker of carbon dioxide**, sealing the absorbed gas as stable magnesium carbonate mineral. In Oman alone, there is a mountain that contains some 30,000 cubic km of peridotite.

Another option could be the **basalt rock cliffs**, which contain holes – solidified gas bubbles from the basalt's formation from volcanic lava flows millions of years ago. Pumping carbon dioxide into these ancient bubbles causes it to react to form stable limestone – calcium carbonate.

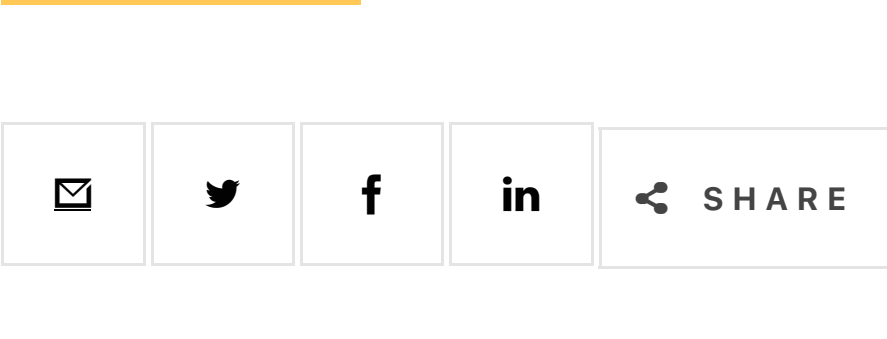
These carbon dioxide absorption processes occur naturally, but on geological timescales. To speed up the reaction, scientists are experimenting with dissolving the gas in water first and then injecting it into the rocks under high pressures.

However, Lackner thinks the gas is too useful to petrify. His idea is to use the carbon dioxide to make liquid fuels for transport vehicles. Carbon dioxide can react with water to produce carbon monoxide and hydrogen – a combination known as **syngas** because it can be readily turned into hydrocarbon fuels such as methanol or diesel. The process requires an energy input, but this could be provided by renewable sources, such as wind energy, Lackner suggests.

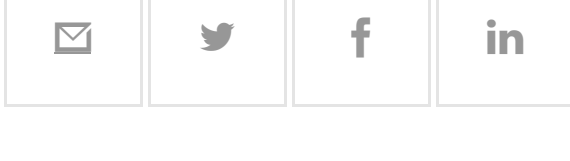
We have the technology to suck carbon dioxide out of the air – and keep it out – but whether it is economically viable is a different question. Lackner says his trees would do the job for around \$200 per tonne of removed carbon dioxide, dropping to \$30 a tonne as the project is scaled up. At that price – which has been criticised as wildly optimistic (the American Physical Society's most optimistic calculations for direct air capture are **\$600 per tonne** of carbon dioxide removed, although the UK's Met Office **is more favourable**) – it starts to make economic sense for oil companies who would pay in the region of \$100 per tonne to use the gas in enhanced oil recovery.

Ultimately, we have to decide whether the cost of the technology is socially worth the price, and that social price is likely to fall as climate change brings its own mounting costs. Economically too, if the price of carbon rises, then this could lead to two effects. Investing in air capture will likely be seen as an equivalent to "avoided emissions". And then it will become a worthy investment.

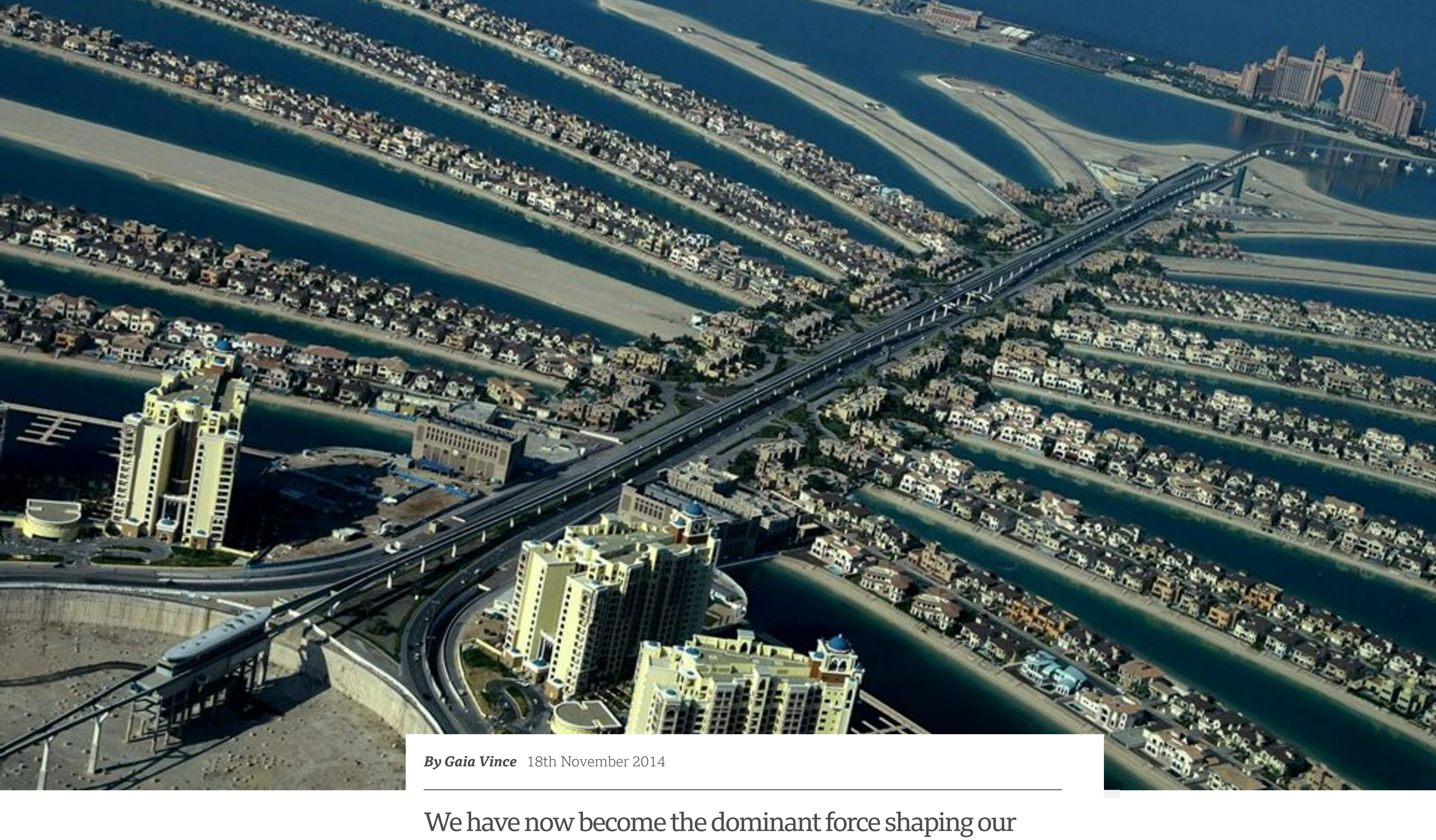
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The Anthropocene: Welcome to the Age of Modern Man



(Image credit: AFP)



By Gaia Vince 18th November 2014

We have now become the dominant force shaping our planet with some saying we have entered a new geological epoch: the Anthropocene or the age of man.

Alien observers monitoring Earth for signs of intelligent life may well have choked on their intergalactic version of tea a few hundred thousand years ago when the first humans stumbled into focus, some 4 billion years after our planet's own emergence. It was obvious that we were a bit special: we could make fire.

As the global climate shifted at the end of the last ice age, some 10,000 years ago, humans put their fire-making skills to great use, blazing a trail across continents to clear trees for grazing and agriculture, enabling societies to develop from hunter-gatherers to rooted civilizations that produced complex technologies. We were even able to improve on our external sources of energy by expanding our range of fuels: rather than relying on what fuel grew in forests and the continual recycling of biomatter, we delved deep into the ground to extract fossil fuels made over geological timescales.

Humans proved so clever and successful that we were able to overcome almost all the environmental limitations that restricted other species to their ecological niches. The

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