published its latest value for Planck's constant, the uncertainty was 12 parts per billion, just over one-quarter of its value in CODATA's previous report — and within the CIPM's requirements.

The CIPM will discuss its next moves during its meeting at the BIPM on 15 and 16 October. This will include a discussion of the draft resolution that is expected to redefine the ampere, mole, kelvin and kilogram at the General Conference on Weights and Measures in 2018. The BIPM is still working on a protocol that will allow teams without access to a watt balance or silicon-sphere set-up to use a new kilogram definition.

There is still scope for upset. The teams have until 1 July 2017 to publish further data before the value of Planck's constant is fixed. Before this deadline, Ullrich's team plans to use a new batch of spheres from Russia in experiments that he hopes will lead to even more-certain values for Planck's constant, but could cause the results to diverge again. "Then we would be in trouble," he says. "But I'm very confident this will not happen." Newell agrees: "This train has a lot of momentum and there has to be something seriously wrong to derail it."

If they are proved right, in 2018, Le Grand K will join the metre as a museum piece. "We'll keep it," says Davis, "but it won't be defining anything anymore." ■

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CLIMATE CHANGE

# Firms that suck carbon from air go commercial

*Two companies announce that they are expanding and upgrading their plants.*

BY DANIEL CRESSEY

It has long been regarded as one of the more blue-skies solutions to climate change. Now two companies have vastly increased their capability to suck carbon dioxide from the air. One, based in Canada, plans to convert captured $CO_2$ into diesel to fuel buses; the other, in Switzerland, will sell it on to a firm that uses $CO_2$ to boost crop growth in greenhouses.

The carbon emissions that this will save are not significant. But David Keith, executive chairman of the Canadian firm, Carbon Engineering in Calgary, and a climate physicist at Harvard University in Cambridge, Massachusetts, says that his company's air-capture plant will position the technology to be further scaled up. Most significantly, he says, the plant will now run the whole process — from $CO_2$ capture to regeneration — for the first time.

Others are excited by the development. "The fact they're getting to commercial-scale prototypes is incredibly encouraging," says Noah Deich, executive director of the Center for Carbon Removal in Berkeley, California.

More than a dozen facilities worldwide, including oil refineries and power plants, already capture millions of tonnes of $CO_2$ from the flue gases they expel. The idea of capturing carbon directly from the atmosphere — where $CO_2$ is present in much lower concentrations than in flue gases and so is harder to extract — has been around for several years, but only in the form of small, demonstration projects.

CARBON ENGINEERING

Carbon Engineering's demonstration plant in British Columbia captures carbon dioxide from the air.

On 9 October, Carbon Engineering officially opened a new plant in Squamish, British Columbia, that can capture and process around 1 tonne of $CO_2$ per day — about the same as a typical car might emit when driven about 5,000 kilometres. This represents a big step up from the company's earlier demonstration plant, which ran only the first step of capture and did not regenerate gaseous $CO_2$.

The plant uses fans to push air through towers containing potassium hydroxide solution, which reacts with $CO_2$ to form potassium carbonate; the remaining air, now containing less $CO_2$, is released. Further treatment of the solution separates out the captured $CO_2$, regenerating the capture solution for reuse. These processes are currently powered by electricity, which in British Columbia is mainly generated by hydroelectric sources, says Keith. Initially, the company will re-release the captured $CO_2$, but Carbon Engineering announced last week that it had signed a Can$435,000 (US$333,000) deal with the province of British Columbia to assess the potential of turning the $CO_2$ into fuel to power local buses.

Meanwhile, the Swiss company, Climeworks in Zurich, announced at a UK meeting on greenhouse-gas capture in Oxford earlier this month that it plans to start capturing $CO_2$ on a commercial scale. Its plant in Hinwil, Switzerland, will capture 1,000 tonnes of $CO_2$ per year starting in mid-2016, according to Anca

Timofte, a process engineer at the company.

In some ways the technology is similar to that of Carbon Engineering, but Climeworks will instead use granules to soak up the $CO_2$, using a module that will sit on top of an incineration plant. (The technology is still classed as air capture because the material will scrub $CO_2$ from air near the plant rather than from the expelled gases.) Waste heat from the incinerator will be used to drive the captured $CO_2$ off the granules, which can then be reused.

The company has arranged to sell $CO_2$ produced in this way to the firm Gebrüder Meier, which will use it to increase crop yields in greenhouses. Climeworks is also assessing the beverage industry as a source of potential customers, says Timofte.

If such companies are to scale up further and make money, one challenge will be finding buyers for their $CO_2$, says Tim Kruger, a geoengineer at the University of Oxford, UK, who organized the Oxford meeting and runs a company, Origen Power, that hopes to generate carbon-negative energy. And it is not clear whether companies will be able to produce $CO_2$ or related products at a price that is competitive enough to attract a wide pool of clients.

In 2011, a report from the American Physical Society (APS) estimated that air capture would cost at least US\$600 per tonne of $CO_2$, assuming a large system that removed 1 million tonnes of $CO_2$ per year. But Climeworks says that its price will be in that range in the first year of its plant's operation, despite being on a smaller scale than the APS example. The company also expects that cost to fall as the technology develops. Keith, meanwhile, says that the $CO_2$ produced by Carbon Engineering's plant is expensive, but emphasizes that it is a pilot; he says that prices of \$100–200 per tonne of $CO_2$ are realistic for the bigger iterations that it is planning.

ELIZA GRINNELL/SEAS, HARVARD

**David Keith, chairman of Carbon Engineering.**

Even if the companies cannot compete on price with conventionally manufactured $CO_2$ (which can be as low as tens of dollars per tonne but can be significantly higher), there are other factors that could help to create demand for air-captured $CO_2$. The introduction of a carbon tax could incentivize big emitters to pay other companies to mop up their $CO_2$ to avoid paying the tax. And if the world is ever to become completely carbon neutral, air capture will have a part to play, says Nilay Shah, an engineer working on low-carbon technologies at Imperial College London.

Efforts to mitigate climate change should focus on capturing $CO_2$ at the source. But there are many scenarios in which pre-emission capture is not viable. "Once you start to get into things like capturing carbon from vehicles or from household boilers, that's much more expensive," says Shah. "You may well be better off capturing $CO_2$ from the air."

Keith emphasizes that his company is not trying to fix climate change on its own. "Air capture has been stuck in a catfight between one group of people saying it's a silver bullet and one group saying it's bullshit," he says. "The truth is it's neither." ■

AWARDS

# DNA-repair sleuths win chemistry Nobel

*Tomas Lindahl, Paul Modrich and Aziz Sancar share prize for work on how DNA heals itself.*

**BY DANIEL CRESSEY**

The 2015 Nobel Prize in Chemistry was awarded last week to three researchers for their work on DNA repair.

Tomas Lindahl, Paul Modrich and Aziz Sancar "mapped, at a molecular level, how cells repair damaged DNA and safeguard the genetic information", said the Royal Swedish Academy of Sciences in Stockholm, which awards the prize.

DNA is not a stable molecule, but slowly decays over time. For life to exist — as Lindahl first realized while working at the Karolinska Institute in Stockholm in the 1970s — there must be repair mechanisms that fight back against this process.

Numerous scientists have since chronicled the many ways in which damaged DNA is patched up, says Stephen West, who works on DNA repair at the Francis Crick Institute in London, where Lindahl is now an emeritus group leader. "The DNA-repair field is a large field," says West. "Many of us thought a Nobel would not go to this field because there are so many people with a claim to the prize."

But the three repair mechanisms recognized with the Nobel prize "are probably the three most important and best-understood mechanisms", he says, adding that the awards are "fantastically well deserved".

### REPAIR JOBS

Lindahl, who is regarded as one of the founders of the field, chronicled a process dubbed base excision repair, in which specific enzymes recognize, cut out and patch up bases in the DNA molecule. Before his work, "I don't think anybody really considered the idea that DNA requires active engagement by a set of housekeeping processes to keep it in a stable state," says Keith Caldecott, who studies DNA repair at the University of Sussex in Brighton, UK, and did postdoctoral work with Lindahl.

Sancar — who was born in Savur, Turkey, but has spent most of his professional life in the United States and is now at the University of North Carolina at Chapel Hill — worked in the 1980s to explain how cells use enzymes to repair damage to DNA from ultraviolet rays or other carcinogens, through a system called nucleotide excision repair.

***"We need DNA repair but we don't like it that the cancer cells have DNA repair."***

And in 1989, Modrich, who is at Duke University School of Medicine in Durham, North Carolina, published work on a third mechanism — 'mismatch repair' — which deals with errors produced when DNA is copied.

This September, the prestigious Albert Lasker Basic Medical Research Award was also awarded for work on how cells correct damage to DNA. But it went to two other researchers: Evelyn Witkin of Rutgers University in New ▶