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Science AMA Series: I spent the last year investigating the potential of carbon-capture technology (or “clean coal”) to mitigate climate change. Ask me anything!

AKSHAT_RATHI R/SCIENCE

Under the goals of the 2015 Paris climate agreement, the world has agreed to do what is needed to keep global temperatures from not rising above 2°C as compared to pre-industrial levels. According to the International Panel on Climate Change, in every economically viable scenario to that goal requires reaching zero emissions and requires the deployment of carbon-capture technologies on large scale.

These technologies allow us to keep burning fossil fuels almost without emissions, while putting us on the trajectory to hit our climate goals. They are considered a bridge to a future where we can create, store, and supply all the world’s energy from renewable sources. But carbon-capture technologies have a tortured history. Though first developed nearly 50 years ago, their use in climate-change mitigation only began in earnest in the 1990s and scaling them up hasn’t gone as planned.

My initial perception, based on what I had read in the press, was that carbon capture seemed outrageously expensive, especially when renewable energy is starting to get cheap enough to compete with fossil fuels. At the same time, my training in chemical engineering and chemistry told me the technologies were scientifically sound. And some of world’s most important bodies on climate change keep insisting that we need carbon capture. Who should I believe?

The question took me down a rabbit hole. After a year of reporting, I’ve come to a conclusion: Carbon capture is both vital and viable. I’ve ended up writing nearly 30,000 words in The Race to Zero Emissions series for Quartz. You can read the 8,000-word story where I lay the case for the technology here: https://qz.com/1144298; other stories from the series here: https://qz.com/re/the-race-to-zero-emissions/; and follow the newsletter here: https://bit.ly/RacetoZeroEmissions.

I'll be back at 11 ET (16 UTC) to answer questions. You can ask me anything!

Bio: Akshat Rathi is a reporter for Quartz in London. He has previously worked at The Economist and The Conversation. His writing has appeared in Nature, The Guardian and The Hindu. He has a PhD in organic chemistry from Oxford University and a BTech in chemical engineering from the Institute of Chemical Technology, Mumbai.

1 ET (18 UTC): I've answered all the questions. Thanks for having me!

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WRITE A REVIEW

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How many years of continuous operation would be required in order for a large-scale CCS process to have negative carbon emissions? I mean from the perspective of a life-cycle analysis that considers construction, operation, maintenance and eventual disposal. As your article mentions, steel production releases lots of carbon, and lots of steel would be required to construct the entire facility, especially when a pipeline is factored in. Then, operation itself has a relatively high energy demand.

Since the steel industry has virtually no alternative to fossil-fuels and it has consolidated production to a smaller number of more massive facilities, would you agree that CCS is more likely to be applied to steel facilities, at least initially?

invertedearth

Thanks for the question. Carbon capture and storage (CCS) will never be carbon negative. Even if the technology can capture 100% of emissions from the exhaust of power plant or industry (which it can't),

potential of carbon-capture technology (or "clean coal") to mitigate climate change. Ask me anything!, *The Winnower* 4:e151300.03922 , 2017 , DOI: 10.15200/winn.151300.03922

it will only be carbon neutral. In fact, over its lifetime, power plants with CCS will still have a small positive carbon footprint because of inherent emissions in fossil fuel extraction (such as methane leaks).

Still, it's better to capture 95% of emissions than not capturing any. Especially given that we are far from cutting emissions and getting on the trajectory to avoid catastrophic climate change and that we are planning to burn fossil fuels for decades.

Having said that, there are some types of carbon capture technology that could create negative emissions. A proven but expensive technology is direct air capture (read more here: https://qz.com/1100221) which is essentially like trees but on steroids. Another technology, which is yet to be proven, is bioenergy with CCS (or BECCS), where power plants burning biomass capture all emissions. Because biomass plants are considered carbon neutral (which is debatable), any captured and stored emissions are then carbon negative.

"Without emissions"? What about the incredibly toxic coal ash that gets stuck in big open ponds that like to overflow?

satanicpuppy

I said "almost without emissions". I expand on why CCS alone cannot be zero emissions here.

You're right that fossil fuels have other environmental impacts beyond climate change. But if we are going to keep burning fossil fuels (which seems to be the case if you ask any global body), then we must do carbon capture but also improve regulations to reduce other environmental impacts of fossil fuels.

Hi and thanks for joining us today!

Are we any closer to reaching a global consensus on a price for carbon?

Is a massive network of carbon collectors powered by renewables a pipe dream or is there real potential for such a thing?

PHealthy

Thanks for the question.

No, I don't think we are anywhere near consensus on a price for carbon. There isn't one among governments or even among academics. That's one reason why a global emissions trading scheme, like the one in Kyoto, never took off. Policy folks tell me that the quickest way to get climate action is to levy carbon taxes. I wrote about a scheme from US Republicans, which is quite attractive if you like the economics of the right (https://qz.com/905688):

First, creating a gradually increasing carbon tax. Second, returning the tax proceeds to the American people in the form of dividends. Third, establishing border carbon adjustments that protect American competitiveness and encourage other countries to follow suit. And fourth, rolling back government regulations once such a system is in place.

As for carbon collectors powered by renewables, it's not a pipe dream in one sense: we have the technology and it's called "direct air capture" (read more here: https://qz.com/1100221). But it is expensive and at some point the world will be faced with the question whether it wants to suffer the damage of climate change, install these machines, or go for geoengineering with unknown side-effects (https://qz.com/1145525).

This always feels "too goo to be true." Why is it not?

sciencereader3455

Honestly, that's the reason I took up this project. There was so much positive and negative hype around carbon capture technologies that i wanted to find out the answer for myself.

As with anything, the answer is complicated. As I write in my piece, if nothing else, we need carbon capture technologies for industries (cement, steel, ethanol, etc) because their chemistries are such that they will emit carbon dioxide. And, interestingly, there are already carbon capture technologies available off the shelf that can do the job. So that's the part that shows why it's not "too good to be true."

Where it gets less rosy is that, till we have a price on carbon or a carbon tax, it'll be cheaper to dump carbon dioxide in the air than to capture it. And policy movement towards that is really slow. So may be, even if we have the technology, we may never end up deploying it at scales that will have an impact on our fight against climate change.

How cost- and resource-effective is carbon capture at sequestering CO2 from the atmosphere compared to biological sinks, like highly productive forests?

Hovenbeet

Biological sinks are much better value for money. Forests and land-use change have a lot of potential to store carbon. But the problem is that even with those, we won't have enough to put away all the emissions that we need to. For instance, a recent PNAS study concluded: "Natural climate solutions can provide 37% of cost-effective CO2 mitigation needed through 2030 for a >66% chance of holding warming to below 2 °C."

It's likely we will need both natural solutions and direct air capture or BECCS (which I expand upon in this answer).

So how do we enact policy to support the science?

adenovato

There are plenty of options but all require some sort of regulation: either a carbon price (in the form of an emissions trading scheme, which is in play in Canada, Europe, California, and likely to come to China) or a tax on emissions (in play in Norway). Short of that, currently in the US, the 45Q tax credit will enable industry to get credits for doing carbon capture. I address more deeply in this story under the section "Conquering the cost conundrum".

Can you give an ELI5 of the chemical and mechanical processes involved? Thanks!

weedNSATAN

Wow, ok, that's a challenge. Here's a try.

When we breathe or burn wood, we put out a gas called carbon dioxide. It leaves us but remains on our planet. That would not be a problem normally, but this gas also traps sun's heat and the more of it there is in the world the more harm it will cause.

To get rid of the gas, some people have built machines to trap it. It works because the gas a special power, it can be mixed with water. If you take lots and lots of water and pass many gases through it, it will only trap carbon dioxide. That water can then be buried deep underground, where the carbon dioxide becomes stone.

Has a sustainable method for storage or conversion been developed here?

You have a chem E background, so maybe you've seen some new breakthroughs (perhaps just theoretical solutions) here, even something as simple as a photosynthesis from some super-algae. Just dumping CO2 underground seems like a terrible plan for anything other than as a grid balancing emergency power plant.

bilfdoffle

Not sure I understand what "sustainable storage" means.

These are not theoretical solutions. What I can say is that we've been burying CO2 underground since the 1970s. Currently we have more than 220 million tons of anthropogenic CO2 that's been buried (most in the US). I would urge you to read the big feature story on the tech: https://qz.com/1144298

And, yes, it's not an ideal solution. But the urgency of action on climate change is so large that environmentalists want all options accelerated. If the world will continue to burn fossil fuels (and that it seems bent on doing) or produce cement, steel or ethanol, then carbon capture has to be part of the solution.

With an increasing number of countries pledging to ditch coal and the big fossil fuel companies finally investing hugely in carbon neutral renewables with zero emissions, why is technology that still releases carbon and produces other pollutants an advantage?

plups

It's an advantage because countries haven't pledged enough. The UN Emissions Gap report makes it clear that we are not on track to keep temperature rise below 2C. If anything we're going above 3C.

As I say in this answer, it's not an ideal solution. But the urgency of action on climate change is so large that environmentalists want all options accelerated. If the world will continue to burn fossil fuels (and that it seems bent on doing) or produce cement, steel or ethanol, then carbon capture has to be part of the solution.

Carbon-capture technology sounds like a necessary step in controlling our C02 levels but why do you add (or "clean coal")? Carbon-capture without coal, "clean" or otherwise, would be an actual better the environment instead of mitigating the damage done by burning coal on the first place. Should we not be weaning ourselves off of coal instead of looking for ways to use more of it with fewer immediate consequences? Apologies for the pessimism.

Charlitos_Way

We should. I put them in bracket because "clean coal" is widely misunderstood. It stands for a whole set of technologies that can reduce any emissions from coal. In the 1960s, clean coal technologies were to reduce mercury emissions, then sulfur emissions. Today, they are to reduce carbon emissions a little bit but not always >95% (which is something you can do with carbon capture). I expand upon the problem with the phrase "clean coal" in this answer.

We should do all we can to reduce emissions. Carbon capture can go a much longer way than other "clean coal" technologies. It's best to keep the distinction clear.

Given that resources and money are limited, what are the main arguments in favor of states and private actors investing in CCS rather than in renewables and energy storage? I'm talking mostly about the power and transportation sectors here.

zmobie_slayre

The International Panel on Climate Change said in its fifth assessment that without carbon capture the cost of reaching climate goals will be more than double (138% more, to be precise).

The argument is simple. The world has spent hundreds of trillions (compared to $2 trillion for renewables in the past 10 years) in building infrastructure for fossil fuels, and so there's no way to abandon them without a huge economic penalty. And time is running out. Better then to put on carbon capture, so that at least we reach goals than overshoot and spend more capturing carbon dioxide from the air later or suffer worse effects of climate change.

I think you'll enjoy reading the section "Vote your mind" in my feature, especially the London sewer story. https://qz.com/1144298

What's the best way to tackle the widespread bad reputation of "clean coal"?

PickledPokute

We should start with separating "clean coal" from carbon capture and storage (CCS). As I write in my story (https://qz.com/1144298):

The term “clean coal” is a huge problem... Current so-called “clean-coal” technologies nearly eliminate sulfur and mercury emissions, but they don’t reduce carbon emissions.

The trouble is that environmentalists conflate “clean coal” with CCS. If the world is to hit zero emissions, we will need to apply CCS not just to coal power plants but also to natural-gas power plants and then to every carbon-emitting industry. In other words, CCS really isn’t about coal. We cannot afford that confusion any more because time is running out. Ultimately, whether or not CCS is deployed will come down to people, who through their elected governments, can push for the right policies to be adopted.

Second, we should educate people. One reason for writing this series was to help people understand climate math and show that the goal is not use one technology over another but to reach zero emissions and soon. Among the energy industry there is a false sense of optimism that renewables will do it all. They will at some point in the future, but not soon enough to hit climate goals.

Third, governments can help. Progressive countries that understand the use of CCS need to work with those that do not to come to a conclusion that will enable deployment of the technology. To some extent, this is happening Europe already but it needs to spread across the world.