

# Low-carbon technologies 'no quick-fix', say researchers

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Could replacing coal-fired electricity plants with generators fueled by natural gas bring global warming to a halt in this century? What about rapid construction of massive numbers of solar or wind farms, hydroelectric dams, or nuclear reactors—or the invention of new technology for capturing the carbon dioxide produced by fossil-fueled power plants and storing it permanently underground? Nathan Myhrvold of Intellectual Ventures teamed up with Carnegie Institution's Ken Caldeira to calculate the expected climate effects of replacing the world's supply of electricity from coal plants with any of eight cleaner options. The work was published online by *Environmental Research Letters* on February 16.

In each case, Myhrvold and Caldeira found that to achieve substantial benefit this century, we would need to engage in a rapid transition to the

lowest emitting energy technologies such as solar, wind, or nuclear power – as well as conserve energy where possible. The researchers found that it takes much longer to curtail the warming of the Earth than one might expect. And in the case of natural gas—increasingly the power industry's fuel of choice, because gas reserves have been growing and prices have been falling—the study finds that warming would continue even if over the next 40 years every coal-fired power plant in the world were replaced with a gas-fueled plant.

"There is no quick fix to global warming," Caldeira said. "Shifting from one energy system to another is hard work and a slow process. Plus, it takes several decades for the climate system to fully respond to reductions in emissions. If we expect to see substantial benefits in the second half of this century, we had better get started now."

Researchers have previously conducted studies projecting the long-term climate effects of rolling out a single new energy technology. But this work from Myhrvold and Caldeira is the first to examine all the major candidate technologies for replacing coal power—including conservation—and to examine wide ranges of possible assumptions about both the emissions each technology generates and also the scope and duration of the build-out.

"It takes a lot of energy to make new power plants—and it generally takes more energy to make those that use cleaner technology--like nuclear, solar, and wind--than it does to make dirty ones that burn coal and gas," Myhrvold added. "You have to use the energy system of today to build the new-and-improved energy system of tomorrow, and unfortunately that means creating more emission in the near-term than we would otherwise. So we incur a kind of 'emissions debt' in making the transition to a better system, and it can take decades to pay that off. Meanwhile, the temperature keeps rising."

The study used widely accepted models relating emissions to temperature. The two researchers also drew on a rich literature of studies, called life-cycle analyses, that total up all the greenhouse gases produced during the construction and operation of, say, a natural gas plant or a hydroelectric dam or a solar photovoltaic farm. It also examined the potential that technological improvements, such as advances in carbon capture and storage or in solar panel efficiency, could have on outcomes.

"It was surprising to us just how long it takes for the benefit of a switch from coal to something better to show up in the climate in the form of a slowdown in global warming," Caldeira said.

"If countries were to start right away and build really fast, so that they installed a trillion watts of gas-fired electricity generation steadily over the next 40 years," Myhrvold said, "that would still add about half a degree Fahrenheit to the average surface temperature of the Earth in 2112—that's within a tenth of a degree of the warming that coal-fired plants would produce by that year."

The researchers found that coal- or gas-fired plants equipped with carbon capture and storage may also have good potential eventually, but that substantial advances in technology are still required for it to be able to substantially reduce the amount of climate change.

The results from this study suggest that policies aimed at combatting global warming should aim at faster, larger-scale transitions that reduce electricity use where possible, while building wind, solar, and nuclear plants, to meet the growth in demand for electricity.

**More information:** 'Greenhouse gases, climate change and the transition from coal to low-carbon technologies,' Myhrvold N P and Caldeira K 2012 Environ. Res. Lett. 7 014019.

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