Human behavior sabotages carbon dioxide-reducing strategies

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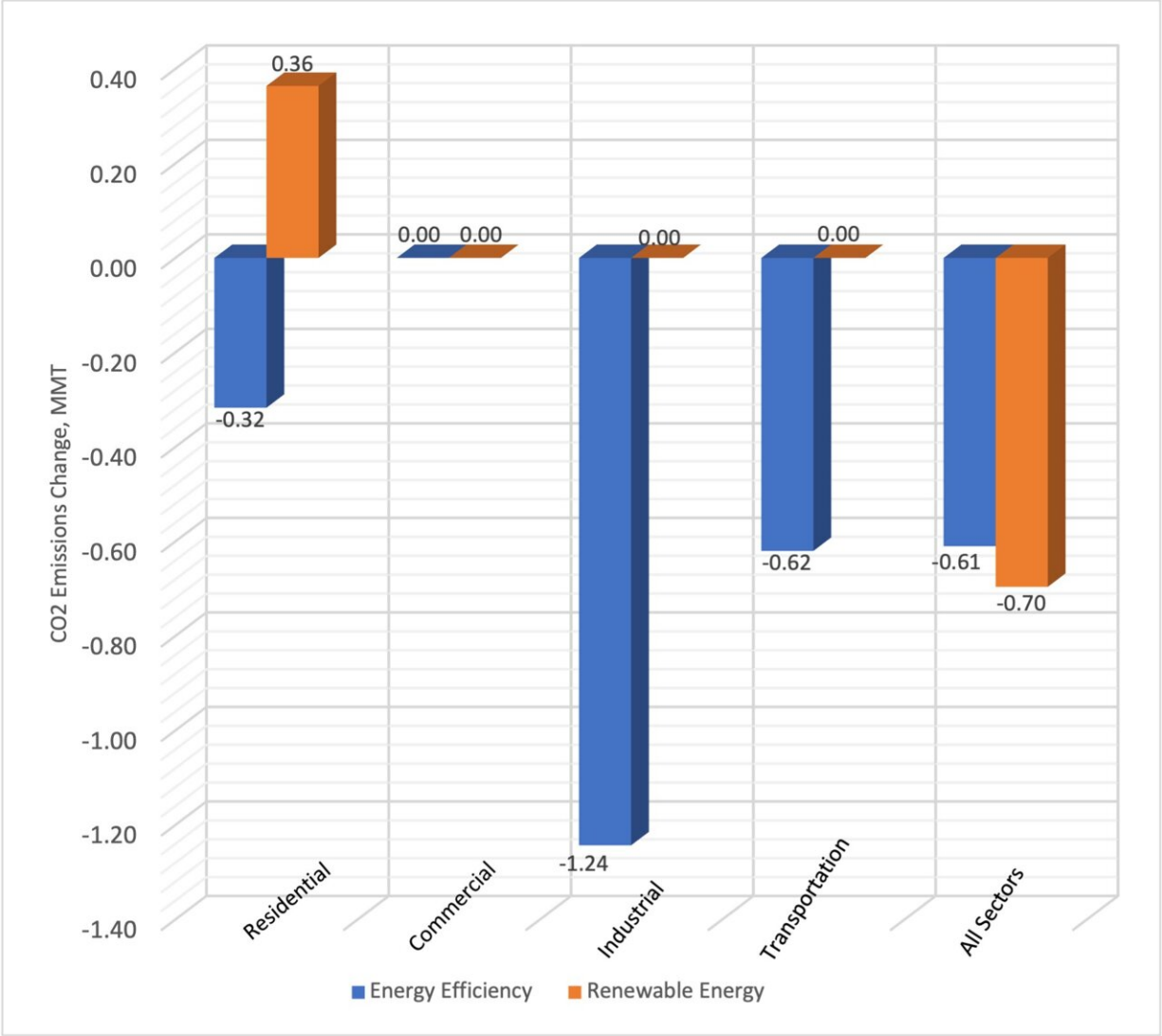

Change in CO_2 emissions for each 1% increase in energy efficiency and renewable energy. In all the sectors combined, both energy efficiency

improvement and renewable energy sources result in reductions in CO_2 emissions: a 1% increase in each of energy efficiency and renewable energy sources results in 0.61% and 0.70% reductions in CO_2 emissions respectively. In the commercial sector, both energy efficiency improvement and renewable energy development, practically, do not lead to statistically significant reduction in CO_2 emissions. Energy efficiency improvement results in some reductions in CO_2 emissions in the residential, industrial, and transportation sectors. Most surprisingly, a 1% increase in renewable energy sources generates nearly 0.4% increase in carbon emissions. Credit: Lazarus Adua

For the past 150 years, humans have pumped extraordinary amounts of greenhouse gasses, such as CO_2, into the atmosphere and warmed the planet at an alarming rate. To slow down climate change, societies tend to focus on two solutions for reducing greenhouse gas emissions: improving energy efficiency and developing and using renewable energy sources. United States President Joe Biden's climate agenda includes a large effort to upgrade buildings to be more efficient and proposes investing billions of dollars for clean energy research. But are these strategies working as we expect?

A new study by University of Utah researchers compared every U.S. state's CO_2 emissions with their investment in the two solutions from 2009 to 2016. The authors found no statistically significant difference between energy efficiency improvement and renewable energy development—both resulted in some reductions in CO_2 emissions when considering all societal sectors, although renewable energy investment was slightly more impactful.

The findings revealed two surprises. First, state governments' policies aimed at helping consumers improve energy efficiency had no effect on CO_2 emission. Rather, states with economy-wide lower energy input per each unit of economic output (per capita gross domestic product, GDP)

emitted lower levels of the greenhouse gas. Second, investment in renewable energy sources led to increased levels of CO_2 emissions in the residential sector. These outcomes are evidence of a well-known phenomenon called the rebound effect that describes when people respond to saving energy by consuming more, negating the benefit of CO_2 reduction.

"Lots of energy analysts tend to look at emissions as a technical problem that requires a technical solution; build more efficient vehicles, build homes to use less energy. What they don't consider is human behavior. If you've got a hybrid car, the money you save on gas might allow you to drive more," said the study's lead author Lazarus Adua, assistant professor of sociology at the U. "My goal here is to let policymakers know that this rebound effect is a problem, and they need to address it. If you're only paying attention to improving efficiency and investing in renewables, you're not going to solve the problem."

The study was published on Aug. 25, 2021, in the journal *Global Environmental Change*.

Energy efficiency improvement and renewable energy production

To assess each state's energy efficiency improvement investment, the authors used two measures. The first is the American Council on an Energy-Efficient Economy's scoring of U.S. states on policy initiatives aimed at improving energy efficiency in households or other buildings. The second is the state's economic output per each British Thermal Unit (BTU) of energy consumed. This reveals how efficiently the economy uses energy to produce every dollar of GDP. To assess renewable energy production, Adua and his team calculated the proportion of a state's total energy consumption from renewable energy sources, such as wind, solar,

geothermal or hydropower.

They analyzed each solution's impact on CO_2 emissions across four sectors individually— residential, commercial, industrial, transportation—and the impact across all sectors combined.

The findings show that a 1% improvement of the economic output per BTU results in reduced CO_2 emissions in residential, industrial and transportation sectors, confirming that overall improvement in production efficiency across society is beneficial. There's no rebound effect because an individual probably won't notice if they save money due to a more efficient economy. In contrast, a state's energy efficiency policy scores had no statistical effect on CO_2 emissions in any of the sectors. This is probably because they worked too well to save residents money and may have encouraged them to consume more elsewhere, Adua said.

Renewable energy had a more complicated story. The study found that increasing renewable energy by 1%, resulted in a 0.69% reduction in CO_2 when all sectors were combined. However, the residential sector on its own had the opposite result—a 1% increase in the amount of renewable energy led to a 0.36% increase in CO_2 emissions. On the surface, the result seems counterintuitive. But to sociologist Adua, it makes perfect sense.

"It's unexpected, but it's not very surprising given what I know about human attitudes towards consumption and the use of resources. When people think they are already doing right for the environment, they begin to lose sight of other ways in which they harm the environment. They may also feel justified to consume a little bit more. And before you know it, the benefit of the solar panel is basically canceled out by increased consumption in other areas," said Adua.

The next steps for Adua and the authors is to go deeper into some of the findings, focusing on the residential sector. With more funding, he'd like to conduct survey-type studies with respondents who have renewable energy at home versus those without it, and gage their attitudes towards general environmental protection. Additionally, Adua is developing a book that breaks down the positives and negatives of proposed methods aimed at mitigating climate change, including tactics to physically remove CO_2 from the atmosphere.

"Every climate change solution has consequences. Investment in renewables means that we must expand mining to get the metals needed for batteries. Some mines being proposed are on land sacred to Native Americans and could cause environmental pollution," said Adua. "My goal is to provide policy makers with as much information as I can to make decisions about how to tackle the climate crisis."

Adua reiterated that focusing solely on technical solutions will fail to solve the climate crisis.

"We need to think about these solutions more holistically, you have to think about restructuring the society in ways that will make it more efficient overall," said Adua. "But when you talk about structural change, people are just thinking, 'that will destroy our way of life.' But if we don't solve that problem today, the environment will change our way of life for us. Maybe not our generation, but our descendants, the environment will change their way of life."

More information: Lazarus Adua et al, Seeking a handle on climate change: Examining the comparative effectiveness of energy efficiency improvement and renewable energy production in the United States, *Global Environmental Change* (2021). DOI: 10.1016/j.gloenvcha.2021.102351

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