Captured water, carbon dioxide from car exhaust could help grow food

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What if both the water and carbon dioxide (CO_2) produced from a vehicle's exhaust system could be captured and used for growing food? Repurposing these two wasted products would be a game changer for reducing the carbon footprint of roadway traffic and helping the agricultural industry feed a growing human population.

Three faculty members at Texas A&M University, Maria Barrufet, Elena Castell-Perez and Rosana Moreira, have written a white paper reporting their initial analysis and published it in hopes of obtaining the funding needed for doing formal, multidisciplinary research on the project.

"I started reading the related literature and did simulations of what was possible," said Barrufet, professor and Baker Hughes Endowed Chair in the Harold Vance Department of Petroleum Engineering. "This is entirely realistic. Several proposals have already been written for large trucks and marine vehicle applications, but nothing has been implemented yet. And we are the first to think of a passenger car engine."

The impact could be enormous. In 2019, the number of vehicles estimated to be in use around the world was 1.4 billion. An average passenger car in operation can emit about 5 U.S. tons (approximately 4.6 metric tons) of CO_2 per year, meaning a significant amount of greenhouse gas is going into the environment. One car's fuel combustion also creates a large amount of water per year—about 5,547 gallons (approximately 21,000 liters).

Castell-Perez and Moreira, both professors in the Department of Biological and Agricultural Engineering, know this wasted CO_2 and water could be put to good use, especially in cities. Recent expansions in U.S. urban agriculture rely on industrial greenhouses, which use an artificially enriched atmosphere containing up to three times the amount of CO_2 in normal air to improve plant health and harvests. These urban farms would greatly benefit from a steady source of free, reclaimed CO_2 and water as they currently purchase and use almost 5 pounds (over 2 kg) of CO_2 and nearly six gallons (22 liters) of water to grow just over two pounds (1 kg) of produce. And these numbers don't include the water and CO_2 needed for post-harvest food processing and dense-phase pasteurization.

The three faculty members outlined how the integrated device could work. Heat from the engine could power an organic Rankine cycle (ORC) system, essentially a small, closed unit containing a turbine, heat exchangers, condenser and feed pump that works like an old-fashioned steam engine but on a much smaller scale, and with far less heat needed to produce electricity. The ORC would power the other components, such as a heat-exchange system, that could cool, compress and change the CO_2 gas to a liquid for more compact storage.

"Years ago, we didn't think we could have air conditioning in a car," Barrufet said. "This is a similar concept to the air conditioning that we now have. In a simple way, it's like that device, it will fit in tight spaces."

Preliminary simulations are encouraging. No significant reduction in a car's engine power or increase in its fuel use is predicted. Any potential corrosion in the heat exchange system could be addressed with the use of new coating materials. Theoretically, vehicle owners could turn in full cartridges of CO_2 and water at reclamation centers just as people bring in aluminum and steel cans nowadays. Or drivers could even use the CO_2 and water in greenhouse systems of their own or within a community, provided the CO_2 was used responsibly and fully absorbed by the plants.

Questions remain, though, such as how big these cartridges would need to be, how the water would be handled since it cannot be compressed, and at what weight would the stored CO_2 and water affect the car's performance.

Barrufet, Castell-Perez and Moreira are actively seeking funding to continue their work. While research is already in place in national labs and industries on improving devices for large-scale CO_2 capture, nothing currently exists on a scale this small, so it could be 10 years before they have something ready for testing.

The greatest challenge could come from assembling a multidisciplinary team to conduct the research. The components for the device already exist in some form but will need a cohesive team of engineers from different specialties to redesign them to work together in such a confined space.

"All of these independent ideas and technologies have no value if they cannot connect," Barrufet said. "We need people concerned about the future to make this happen soon, energized students in petroleum, mechanical, civil, agricultural and other engineering disciplines who can cross boundaries and work in sync."

More information: Maria A. Barrufet et al, Capture of CO2 and Water While Driving for Use in the Food and Agricultural Systems, *Circular Economy and Sustainability* (2021). DOI: 10.1007/s43615-021-00102-4

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