Net Zero is Easier with Carbon Disposal (Utilization & Storage)

Stanford
Center for Carbon Storage
Carbon Removal Initiative

This brief discusses findings that emerged through a series of interviews held in the spring of 2021, and a virtual workshop held in June 2021, in which over 115 stakeholder participants discussed Pathways to Carbon Neutrality in California.

Get Rid of Carbon, Not Just Creation of Carbon.

The goal of net zero by 2045 requires that California find a pathway such that any CO_2 created in the state be responsibly disposed of. Participants agreed that California will have to massively reduce the amount of CO_2 it creates. One pathway to net zero is "perfect zero" — to produce no CO_2 whatsoever by rigorously eliminating every CO_2 creating-activity without exception. A more flexible pathway to net zero is to balance residual CO_2 creation with equal volumes of CO_2 disposal[1], where this balancing is the "net" in "net zero".

THE PATHWAY OF PERFECT elimination of CO_2 creation has "face value" attractiveness. However, some important economic activities currently have no practical alternative to creating CO_2. Other activities have "edge cases" where the cost or consequences of complete elimination could be unacceptable. Some things people want to do (such as deploy hydrogen at scale) are easier if CO_2 can be created and immediately disposed of. Finally, 2045 is less than two and a half decades away. For these reasons, a diversified portfolio of options, including carbon disposal, can greatly ease the path to net zero. In this brief, we discuss the advantages of pathways that include carbon disposal.

THERE IS NO PRACTICAL ALTERNATIVE AT PRESENT TO FOSSIL FUELS FOR SOME INDUSTRIAL PROCESS HEAT

Several participants identified three industries that require fossil fuels because the necessary industrial process temperatures are higher than can be provided cost-effectively using electricity; these are the manufacture of cement, glass, and steel. These commodities are important; as one participant put it "we will build a new planet in the next 40 years" – i.e., the next 40 years of worldwide construction will equal total prior construction. Another participant said, "we need a Plan B" (disposal) because these industries can't avoid CO_2 emissions.

Research into biofuels, hydrogen, or materials science might yield low- or no-carbon heat sources suitable for these industries at acceptable cost, but for now there is no alternative to fossil fuels and consequent CO_2 creation.

CEMENT MANUFACTURE CREATES CO_2 AS BYPRODUCT

Cement is an essential component of concrete, and concrete is ubiquitous in construction and repair of buildings, roads, and other infrastructure. Participants pointed out that the chemistry of converting limestone into cement produces CO_2 as an unavoidable byproduct, so even if the process heat challenge discussed above could be overcome, the CO_2 byproduct remains. Participants indicated that cement is "10% of concrete but 90% of concrete's CO_2", with roughly 60% of the emissions being byproduct and the rest coming from fuel combustion.

ACTIVITIES WHERE SOME USE CASES MAY NOT REASONABLY BE DECARBONIZED

Many participants indicated that achieving almost-complete decarbonization is relatively straightforward but that driving to 100% is very difficult[2]. One participant spoke of "the challenge of the last 10%", another that "the last 3% of emissions is incredibly expensive". These are expressions of "diminishing returns" which is well-known in economics.

Participants indicated that aviation and shipping pose a challenge. There may be unique decarbonization challenges for people who live off-the-grid or other residents of rural communities which as one participant put it "are disadvantaged".

DESIRABLE ACTIVITIES CREATE CO_2

Participants pointed out the potential net-zero benefits of using hydrogen as an energy source, and that "blue hydrogen" from natural gas, with CO_2 as an unavoidable byproduct, can be an attractive means of obtaining hydrogen provided the CO_2 byproduct is disposed of.

Some participants indicated that using biomass as fuel is inherently net zero, and that as a bonus much of the resultant CO_2 can be disposed of using a technology called BECCS.

ELECTRICAL RELIABILITY MAY REQUIRE SOME GAS GENERATION

Participants broadly agreed that on average sufficient carbon-free electricity will be available. However, some days are not average (e.g., hot fall afternoons with high air conditioning demand), and participants pointed out that there exists a need for "firm dispatchable" electricity. This need could not be met by renewables unless very large amounts of storage were available. Several participants indicated that it will be necessary to use natural gas generation to avoid blackouts, with the need being especially acute when there are multiple extreme-heat days in a row. Several participants saw pathways where, for reliability reasons, California's gas generation capacity (but not emissions) actually increase by 2050.

CO_2 DISPOSAL AT SCALE IS ADVANTAGEOUS

Participants perceived that the most attractive pathways for net zero by 2045 include residual CO_2 creation, and for these pathways, CO_2 disposal is necessary for net zero. CO_2 disposal is advantageous in avoiding the costs, consequences, and risks of pathways that rely on completely eliminating all CO_2 creation.

Fortunately, there are prospects for carbon capture at the source of creation for cement and gas electricity generation (and perhaps glass and steel), which coupled with disposal could enable these industries to operate at net zero. We note that carbon disposal technologies must be effective, permanent, available, and economic, and must be used at scale.

---

1 We use "disposal" to mean locking CO_2 away for the long term through utilization (beneficial use such as adding it to concrete), or storage (sequestering it in geologic formations, in plants and soil, or other means).

2 Although not mentioned by participants, it may be difficult to eliminate emissions from sources including legacy vehicles, fossil-fuel hobbyists (e.g., classic cars and farm machinery), backup generators, gas cooktops, propane use in isolated regions, and low income people who can't afford the capital cost to transition away from gas or fuel oil.

Questions on Making Successful Pathways with Carbon Disposal

DECARBONIZATION

- How can residual carbon creators be identified and allowed (or be shut down)?
- How can disposal be allowed without creating a loophole to make excessive CO2?
- How will the public understand that their sacrifices are not being exploited by carbon creators?

DISPOSAL

- How can quality and longevity of carbon disposal be insured?
- What will be the economics of carbon utilization and carbon storage?
- How can the state insure adequate provision and uptake of carbon disposal technologies?

COORDINATION

- How can residual carbon creation and carbon disposal be balanced in practice?
- Might individual residual carbon creators be forced to link to specific carbon disposers, or might it be managed in aggregate?
- How can "leakage" of importing cement, glass and steel from out of state be managed?

Stanford EARTH

Stanford Woods Institute for the Environment

Stanford | ENERGY
Precourt Institute for Energy

Email **sccs@stanford.edu** for more information | sccs.stanford.edu