Capping CO2 at 450 ppm *without disrupting civilization*

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1. IPCC Recommendation

In its recently released Sixth Assessment Report, AR6, the IPCC gives five ways to meet 1.5 °C *by 2030.*

1. Renewables: Electric transport, all electric kitchens, etc.
2. Reuse/recycling
3. Land use changes (reduce deforestation)
4. CCS/CCU *where emitted*
5. Civil engineering (cities, buildings, waste management)

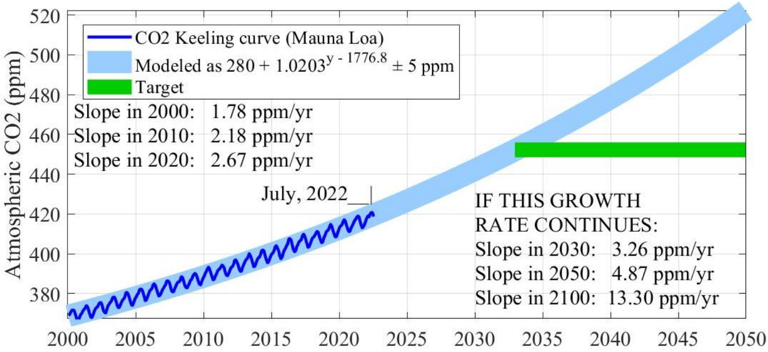
Problem 0: All five recommendations disrupt civilization.

This makes 2030 completely unrealistic.

Solution 0: Drop "where emitted" from CCS.

That's it, we're done. The rest is just corroborative detail.

Problem 0 as a graph



2. Improved recommendations

Problem 1: All five IPCC recommendations are hard to quantify.

Solution 1: Replace 1.5 °C target by a CO_2 cap of 450 ppm.

Advantages

1. Easier to design to (the numbers are precisely known)
2. Impact measurable much sooner (Keeling curve)

Problem 2: All five disrupt civilization, and so will take many decades.

Solution: adopt CCS/CCU but as Direct Air Capture, DAC,
also known as Carbon Dioxide Removal, CDR.

Advantages

1. No disruption of civilization
2. Location independent: Land or sea

3. Target rate and cost

Target: By 2033, remove 27 GtCO2 per year.

Claim: This will cap CO2 at 450 ppm.

Problem 3: At the current offer of about \$100/ton, this would cost about \$2.7 trillion a year.

This is unaffordable.

Solution: Design for a payout of \$10/ton = \$270 billion per year.

This has a prayer of being affordable.

4. Advantage of ocean over land

Carbon Capture and Utilization, CCU:

Problem 4: What market can utilize 27 GtCO2/yr?

Solution: Don't depend on CCU

Carbon Capture and Storage, CCS:

Problem 5: What storage can absorb 27 GtCO2/yr?

Solution: Ocean has more storage + free dispatchable energy

The latter is key to affordability.

5. Quantifying the economics

27 GtCO2 per year turns out to occupy 1.5 km^3 of air per second.

At a velocity of 300 meters per second, this air must pass through 500 hectares (2 square miles)

A floating unit with 15 mouths each 30 m wide is about 1 hectare (about 2.5 acres)

Hence we need 500 units floating independently around the ocean

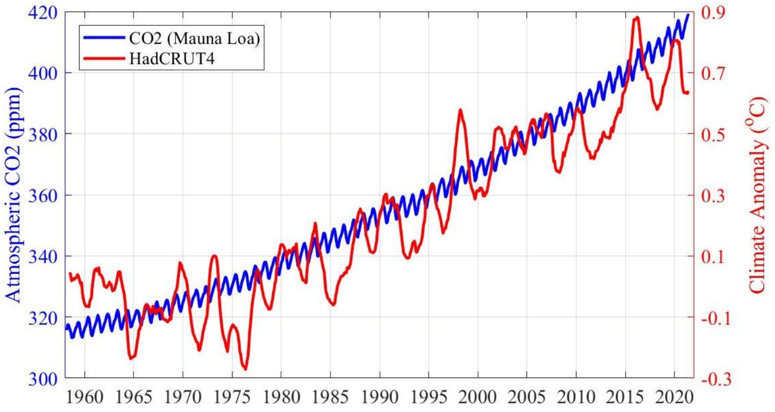
Each unit to cost at most $5.4 billion assuming a lifetime of 10 years.

Or $10.8 billion if 20 years.

If unit cost can be reduced to $1 billion, or $70 million per mouth, CO2 can be removed at about $1 per ton.

LET'S GET STARTED!

Drunken climate



Thermocline heat engine

In thermodynamics, a heat engine draws heat from a hot thermal reservoir and sends it to a cold one. This concept originated in 1824 with French engineer Sadi Carnot, after whom the Carnot cycle is named.

In tropical oceans the oceanic mixed layer or OML is at about 30 °C and sits on the main thermocline where the temperature rapidly declines with depth to 0 °C below the thermocline.

These two heat reservoirs can form the basis for a heat engine that at scale, i.e. when compressing all 1.5 km^3 per second to 5 MPa (50 atmospheres), can generate 45 terawatts of power.

This is three times the power that Earth's entire industrial society consumes.