ACCELERATING CCUS SCALE-UP FOR ACHIEVING CARBON NEUTRALITY

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1956 to Now: Atmospheric CO$_2$ Concentrations

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Carbon dioxide concentration at Mauna Loa Observatory

https://scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-bluemoon/graphs/mlo_full_record.png
Climate Change is Here Today: California Fires Seen from Space


Global Carbon Budget

- **Fossil CO₂**: 35 Gt
- **Land Use Change**: 6 Gt
- **Biosphere**: 12 Gt
- **Atmospheric CO₂ + 18 Gt**:
- **Ocean**: 9 Gt

50% of CO₂ emissions remain in the atmosphere

https://www.globalcarbonproject.org/carbonbudget/19/presentation.htm
We have a carbon budget. If we want to limit warming to 2 degrees C, cumulative emissions of GHG's must remain below the budget (3,400 Gt CO₂).
More Emissions = More Warming

It also means eventually, we need to achieve carbon neutrality.

Net emissions = GHG Emissions – GHG Removal* = 0

*More later on this

IPCC, 1.5 °C Report, 2018.
The Faster We Decarbonize the More Time We Have

Note: these values assume a remaining budget of 1,100 Gt carbon (66% probability of 2°C).
Roles for CCUS

- Carbon neutral transportation fuels
- Electricity production with natural gas to balance renewable generation
- Industrial decarbonization
- Cement decarbonization

9 Gt/year hard to eliminate emissions
CCUS is inevitable

Five Shared Socioeconomic Pathways (SSPs) have been developed to explore challenges to adaptation and mitigation.

Shared Policy Assumptions (SPAs) are used to achieve target forcing levels (W/m²). Marker Scenarios are indicated.

Source: Riahi et al. 2016; IIASA SSP Database; Global Carbon Budget 2017

Now
- Industry
- Load following electricity
- Carbon neutral transportation fuels

Future
- Carbon dioxide removal

Graph showing emissions from fossil fuels and land-use change (GtCO₂/yr) from 1980 to 2100.
Where do we stand with CCUS today?

- 19 projects, on track for 24 by early 2020s
- 39 Mt CO$_2$/year
- CO$_2$-EOR at 65 Mt CO$_2$/year, but mostly from natural sources
- Capture, compression, transport and storage done at scale today
The CCUS Ambition Gap

- ~1-5 Gt/year by 2040 is needed
- Need to double growth rate for 1 Gt/yr in 2040
- Tripple rate or 5 Gt/yr

Mt CO₂/year

Historical record

The Ambition Gap

20%/yr

8%/yr
Is Gt/year scale CO$_2$ storage possible?

Over 3.2 Gt/year of oilfield brine and municipal water is injected underground in the U.S. alone (>150,000 wells).
CCUS Is Not Too Expensive

- Costs of CCUS
  - $40/tCO₂ for high purity sources (NPC, 2020)
  - $70/tCO₂ for cement (EFI&Stanford, 2020)
  - $110/tCO₂ for natural gas combined cycle plants (NPC, 2020)

- Costs for subsidies to stimulate renewable energy and electric vehicles
  - U.S. Renewable Portfolio Standards: $130/tCO₂ (Greenstone and Nath, 2019)
  - Renewable incentives in Germany: Wind at 44 €/tCO₂ and solar at 537 €/tCO₂ (Marcantonini and Ellerman, 2013)
  - Rooftop solar in California: $150 to $200/t CO₂ (CA-LAO, 2020)
  - Utility scale solar in California: $60-$70 (CA-LAO, 2020)
  - Zero emission vehicles in California: $400-$900/t CO₂ (CA-LAO, 2018)
CCUS is an existential strategy for the oil and gas industry: Two futures

Customers and policy makers demand low carbon solutions

CCUS scales slowly

- Decarbonized products are limited
- Policy support is weak
- CCUS is seen as an option of last resort
- Fossil fuels are phased out as rapidly as possible

CCUS scales quickly

- Many decarbonized products are available soon
- Policy support is strong
- CCUS is seen as a valuable climate solution
- Decarbonized fossil fuels are a major part of the energy system

Negative Emissions
What Are We Waiting For?

- CCUS is not too expensive, too immature, or too risky
- CCUS has lacked the policy incentives made available to energy efficiency improvements, renewables, and zero emission vehicles
- 45Q is a good step forward, but it is not enough
  - $35/tCO₂ for EOR
  - $50/tCO₂ for saline formations
- Bankable incentives for promoting scale-up of CCUS are needed
  - Incentives for carbon-neutral gasoline and diesel
  - Power purchase agreements or contracts-for-differences for NGCC with CCS
  - Industry-specific incentives for carbon neutral products
References


  [Link](https://lao.ca.gov/Publications/Report/3912).


  [Link](http://ceep.remit.edu/files/papers/2013-005.pdf)