CLEAN AIR TASK FORCE

The Role of Carbon Capture and Storage Incentives in Ammonia Fuel Production

Presentation to AIChE Annual Meeting

Ammonia Energy Conference

November 2019

Orlando, FL

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About Clean Air Task Force

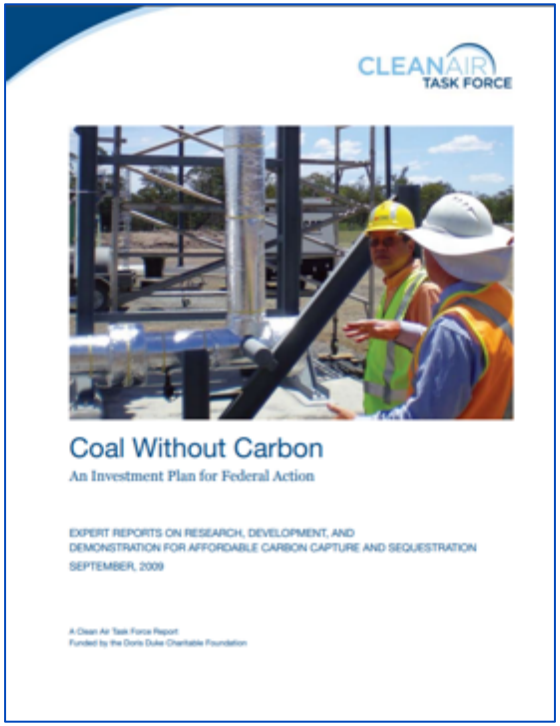
Our Mission
Push the change in technologies and policies needed to get to a zero-emissions, high-energy planet at an affordable cost.

Our Goal
Achieve zero-emissions energy, waste, agricultural, and forest management systems by 2050.

Our Vision
Meet the world's rising energy demand in a way that is financially, socially and environmentally sustainable.

Our Funding
Annual budget about $6 million. Grants from private foundations and individuals, no industry funding.

Examples of previous CATF work on low-carbon fossil energy

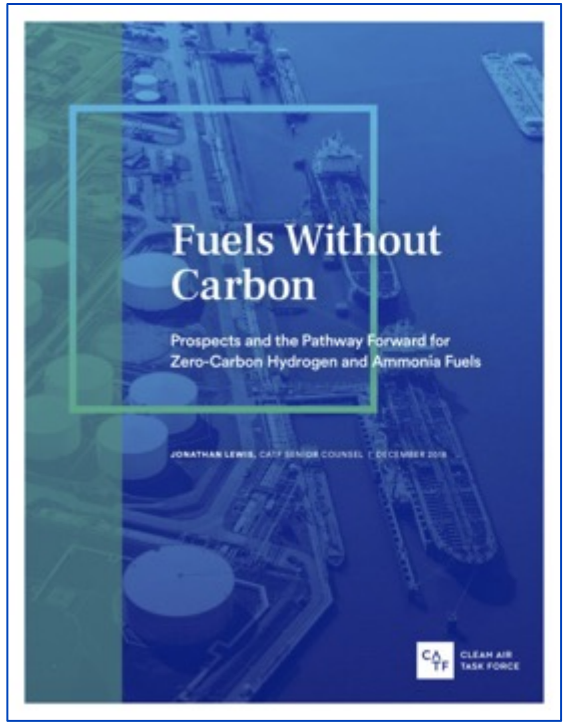


Profiles of technologies with potential to reduce costs of low-emitting fossil energy (2009), including:

- Geological carbon sequestration
- Post-combustion CO2 capture
- Coal Gasification
- Underground coal gasification

Based on expert content from MIT, LLNL, Tufts, and the private sector.

https://www.catf.us/resource/coal-without-carbon/

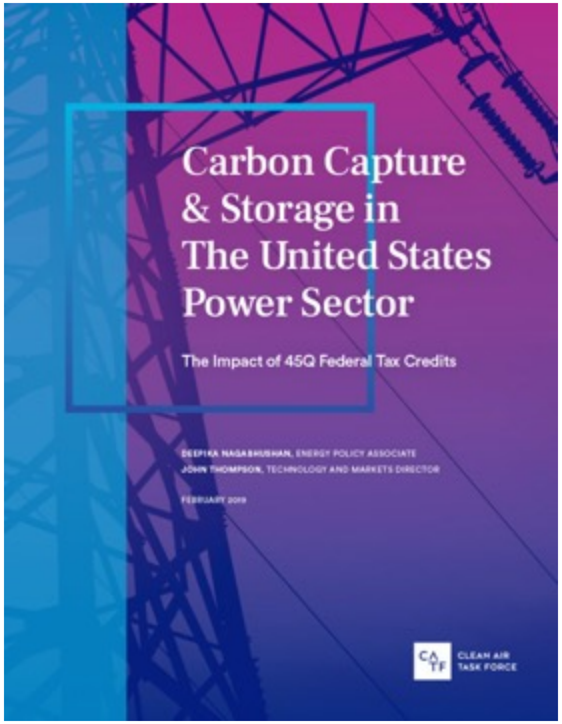


Initial exploration of how production and use of zero-carbon hydrogen and ammonia might help decarbonization (2018), including applications in

- power sector
- industrial sector
- transportation

*** Update and expansion of this analysis currently underway ***

https://www.catf.us/resource/fuels-without-carbon/



Analysis indicating that 45Q tax credit may lead to nearly 49 million tpy CO2 captured by 2030, including:

- Coal retrofits of 41.3 million tpy
- NGCC retrofits of 7.4 million tpy

Based on modeling analysis by Charles River Associates with input from academic and private sector experts.

https://www.catf.us/resource/45q-ccs-analysis/

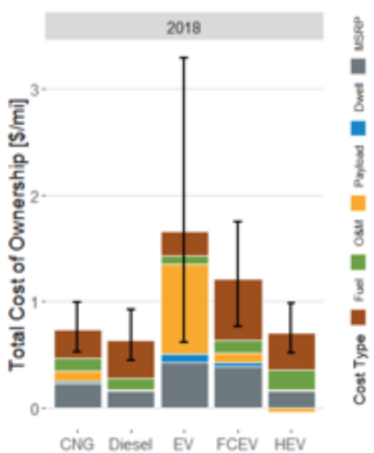
Why zero-carbon fuels? Three examples (among many…)

Heavy Trucking

Toyota's newest hydrogen semi-truck at the Port of Los Angeles. SEBASTIAN BLANCO

Class 7 and 8 trucks (26,000 – 80,000 pounds gross) consumed **~5 quadrillion Btu** of diesel fuel in the US in 2016 (approx. ¾ the demand due to cars).

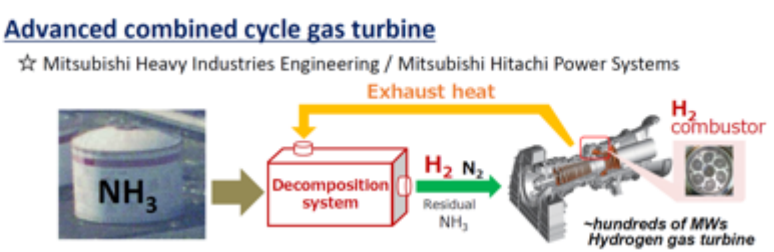
These will be difficult to electrify due to payload, range, and dwell issues. Early economic indicators for these favor hydrogen.



Energy Transport & Storage

US power plans with capacity factor less than ~30% consume **~3-4 quadrillion Btu** of fuel annually. This is one proxy for grid "balancing" energy requirements.

Refrigerated ammonia offers a pathway to very large-scale chemical storage of energy for grid balancing. Energy penalty for cracking back to hydrogen may be small when integrated with CCGT.



Marine Shipping

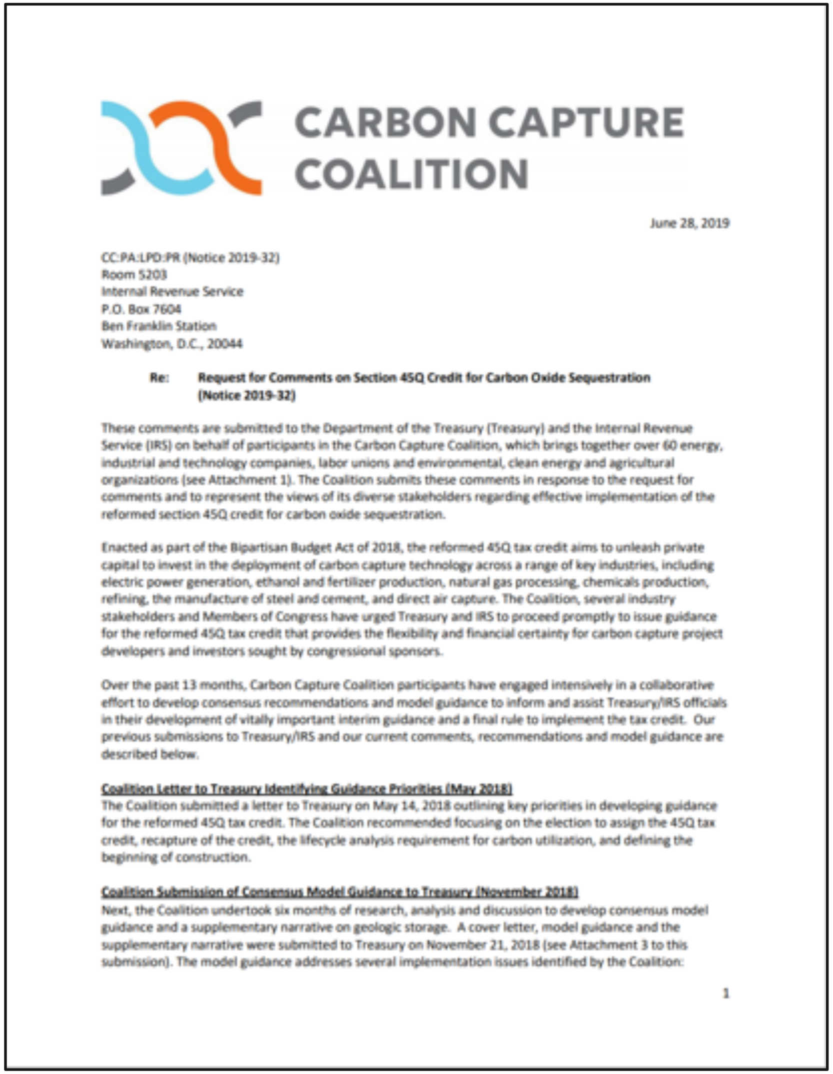
Marine shipping currently consumes **~9 quadrillion Btu** annually, primarily as residual fuel oil.

Roughly half of this fuel is for bulk carriers, container ships, and tankers that will be especially difficult to electrify.

Carbon sequestration tax credits are available to support zero-carbon fuels production

45Q Tax Credit for CO2 sequestration

- Bipartisan Budget Act enacted Feb 2018 expanded and improved the tax credit available for capturing and sequestering CO2 that would otherwise be emitted from a variety of industrial sources; steam methane reformers and similar facilities appear to qualify
- Credit ramps up to $35/t for EOR, $50/t for storage by 2026, at inflation thereafter
- Available for 12 years after in-service for projects commencing construction by Jan 1, 2024, without cap on number of eligible projects or volumes
- The incentive is a credit against income taxes. A party with significant income tax exposure likely needs to be included in the project ownership structure (such as "tax equity investors"); these structures and transferability of the credit are complex.
- Guidance is pending on many issues related to the credit. CATF and other organizations have submitted extensive comments to IRS, and a draft rule is expected in Dec 2019.



CARBON CAPTURE COALITION

June 28, 2019

CC:PA:LPD:PR (Notice 2019-32)
Room 5203
Internal Revenue Service
P.O. Box 7604
Ben Franklin Station
Washington, D.C., 20044

Re: Request for Comments on Section 45Q Credit for Carbon Oxide Sequestration (Notice 2019-32)

These comments are submitted to the Department of the Treasury (Treasury) and the Internal Revenue Service (IRS) on behalf of participants in the Carbon Capture Coalition, which brings together over 60 energy, industrial and technology companies, labor unions and environmental, clean energy and agricultural organizations (see Attachment 1). The Coalition submits these comments in response to the request for comments and to represent the views of its diverse stakeholders regarding effective implementation of the reformed section 45Q credit for carbon oxide sequestration.

Enacted as part of the Bipartisan Budget Act of 2018, the reformed 45Q tax credit aims to unleash private capital to invest in the deployment of carbon capture technology across a range of key industries, including electric power generation, ethanol and fertilizer production, natural gas processing, chemicals production, refining, the manufacture of steel and cement, and direct air capture. The Coalition, several industry stakeholders and Members of Congress have urged Treasury and IRS to proceed promptly to issue guidance for the reformed 45Q tax credit that provides the flexibility and financial certainty for carbon capture project developers and investors sought by congressional sponsors.

Over the past 13 months, Carbon Capture Coalition participants have engaged intensively in a collaborative effort to develop consensus recommendations and model guidance to inform and assist Treasury/IRS officials in their development of vitally important interim guidance and a final rule to implement the tax credit. Our previous submissions to Treasury/IRS and our current comments, recommendations and model guidance are described below.

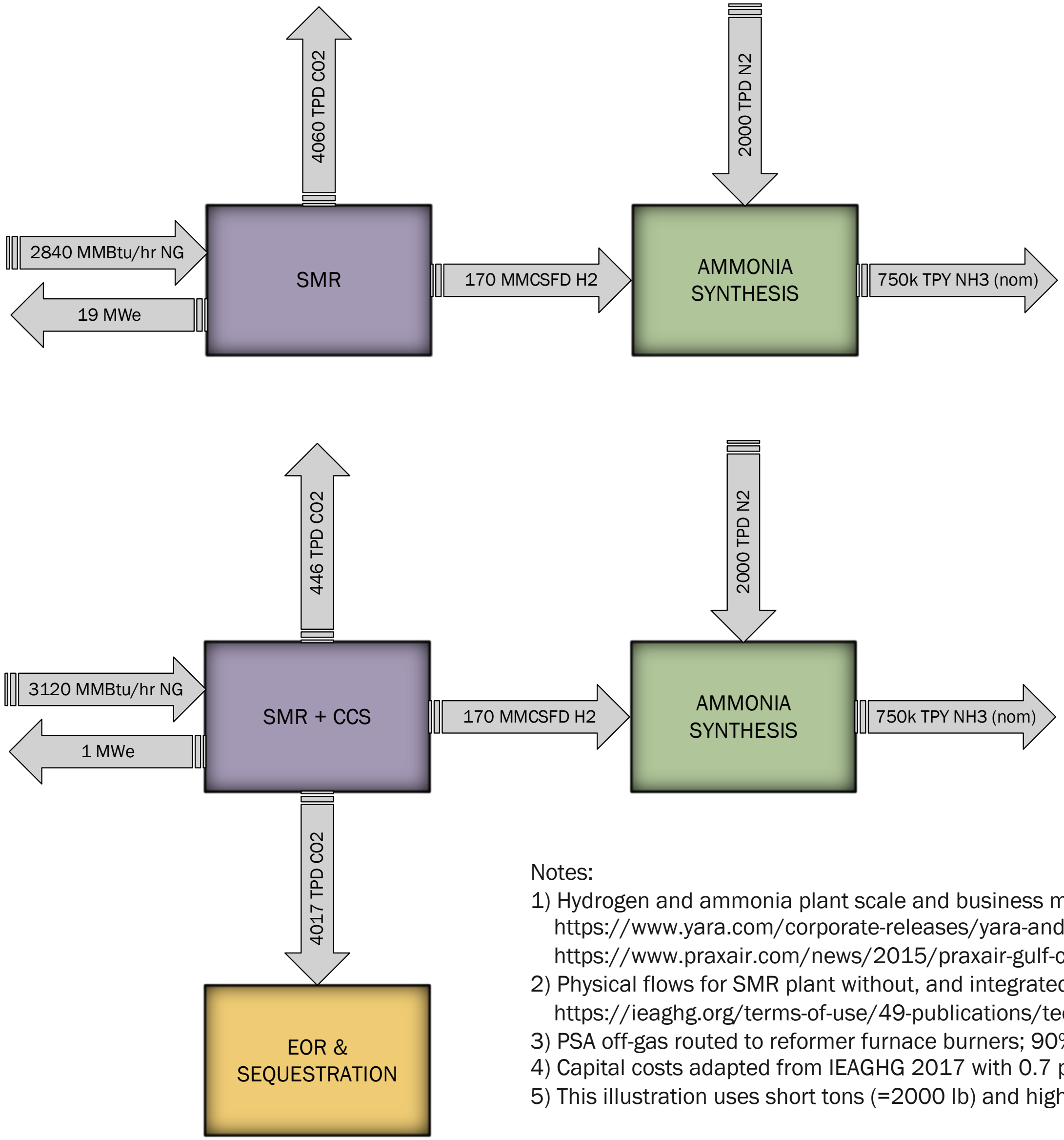
Coalition Letter to Treasury Identifying Guidance Priorities (May 2018)
The Coalition submitted a letter to Treasury on May 14, 2018 outlining key priorities in developing guidance for the reformed 45Q tax credit. The Coalition recommended focusing on the election to assign the 45Q tax credit, recapture of the credit, the lifecycle analysis requirement for carbon utilization, and defining the beginning of construction.

Coalition Submission of Consensus Model Guidance to Treasury (November 2018)
Next, the Coalition undertook six months of research, analysis and discussion to develop consensus model guidance and a supplementary narrative on geologic storage. A cover letter, model guidance and the supplementary narrative were submitted to Treasury on November 21, 2018 (see Attachment 3 to this submission). The model guidance addresses several implementation issues identified by the Coalition:

1

https://carboncapturecoalition.org/wp-content/uploads/2019/06/Final-CCC-submission-to-Treasury-6-28-19.pdf

Hypothetical stand-alone SMR project to illustrate potential value of 45Q incentive for hydrogen, with implications for ammonia



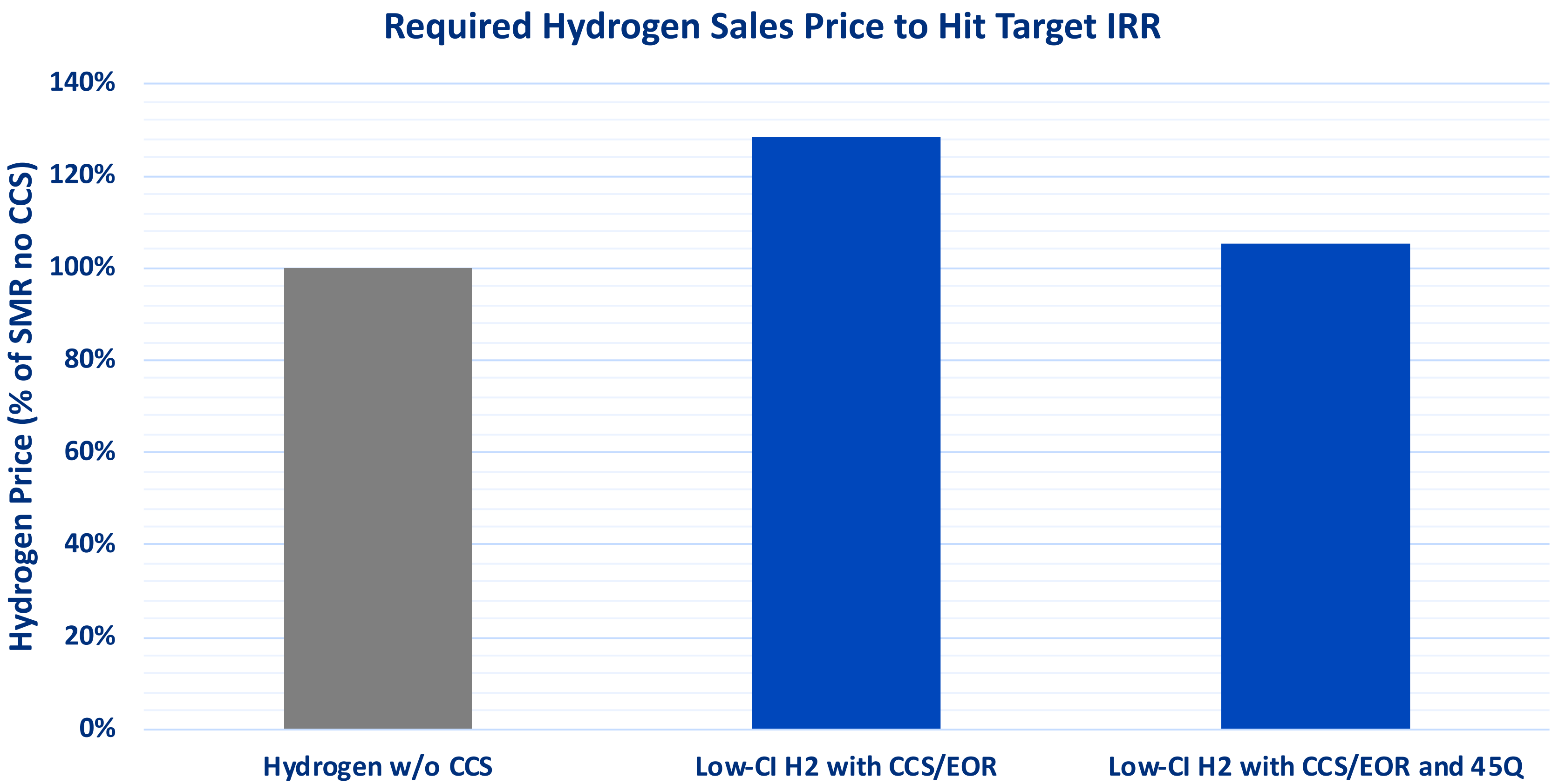
Key Economic Assumptions

ASSUMPTION	VALUE	2026 45Q
SMR TPC	$340M	-
SMR w/ CCS TPC	$607M	-
Owner's Costs	15% on TPC	-
OPEX (Except Feed)	4% of TPC	$27M
Natural Gas	$4/MMBtu	$114M
Electricity	$50/MWh	$0.5M
CO2 Revenue for EOR	$20/ton	$30M
45Q Tax Credit	Ramps	$42M

Notes:

1) Hydrogen and ammonia plant scale and business model from BASF-Yara and Praxair press releases for Freeport Ammonia:
https://www.yara.com/corporate-releases/yara-and-basf-open-world-scale-ammonia-plant-in-freeport-texas/
https://www.praxair.com/news/2015/praxair-gulf-coast-expansion-to-serve-freeport
2) Physical flows for SMR plant without, and integrated with, MEA CO2 PCC scaled from IEAGHG 2017:
https://ieaghg.org/terms-of-use/49-publications/technical-reports/784-2017-02-smr-based-h2-plant-with-ccs
3) PSA off-gas routed to reformer furnace burners; 90% CO2 removed from furnace exhaust (~19% CO2 v/v wet)
4) Capital costs adapted from IEAGHG 2017 with 0.7 power scaling on H2 capacity, adjustment from Euro->Dollar, and inflation
5) This illustration uses short tons (=2000 lb) and higher heating values

This exercise suggests that 45Q can make the cost of producing hydrogen with CCS very close to the cost of producing conventional hydrogen



Key assumptions:

- SMR and CCS are owned by same entity and that entity has the tax appetite to fully use the 45Q credits at face value
- Each case produces 10% unlevered A/T IRR over 20 years of project life
- Although not pictured, Low-CI H2 with CCS but without EOR requires hydrogen price > 150% of "Hydrogen w/o CCS" case

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