Senate Environment & Public Works Committee
The USE IT Act and CCUS Deployment

Dr. S. Julio Friedmann, CarbonWrangler LLC
Written Testimony

Thank you for inviting my testimony – I'm honored to return to this committee. My name is Julio Friedmann, the CEO of Carbon Wrangler. Until recently, I served as the Senior Advisor for Energy Innovation at the Lawrence Livermore National Laboratory. From 2013 to early 2016, I served as the Principal Deputy Assistant Secretary for the Office of Fossil Energy at the US Department of Energy. I have worked for 17 years on clean energy technology development and deployment focusing my work on CCUS, mostly from my positions at Lawrence Livermore National Laboratory.

My last testimony in September focused on carbon capture, use and storage (CCUS). Since then, a sea-change has occurred regarding this critically important sector of the clean energy industry. Much of this is the result of the FUTURE Act, passed into law Feb 9th 2018, which provides substantial incentive to avoid greenhouse gas emissions through the storage and use of CO_2. The act will greatly enhance the ability of commercial CCUS projects to attract financing, and has already re-affirmed the US as the global leader in CCUS technology and policy. Recently, the IEA estimated that the passage of the act will yield projects that capture, use, and store roughly 10-30M tons CO_2 each year in the US.[1]

Because of the financing support the FUTURE Act provided, the rate of CCUS deployment is now limited by a different set of issues. Improvements in conventional carbon capture technology will help position US companies for domestic use and export, although much of this is currently well supported (and managed) by the US Dept. of Energy. However, scrubbing CO_2 from the air (sometimes called direct-air capture (DAC) or "sky mining"), is underrepresented and presents strong opportunities for development. The same can be said for CO_2 conversion and use (CCU, CO2U, or carbon-to-value (C2V)), which present new opportunities for US manufacturing. These technical areas would benefit from new programs to develop and improve their performance and bring technology to the field. NOTE: Many studies have concluded that CCUS is necessary to reach global 2030 climate targets[2] and that greatly expanded CO2U and carbon removal (including DAC) are necessary for the world to reach its climate targets beyond 2050.[3]

Although more technology development would help, the greater barriers to uptake and use of CCUS are uncertainties in policy and regulation. Often, the permitting of pipelines, CO_2 injection wells and certification of storage sites present substantial financial commitments, and may take many years to complete. This adds risk to commercial projects, and ultimately limits investment. Changes to current statute and policy could lead to better coordination between state and federal authorities, and reduce real or perceived barriers to founding projects and deploying this emissions reduction technology. In making changes, care should be taken to ensure that all relevant agencies and stakeholders have a voice and that existing

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[1] https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html

[2] https://wedocs.unep.org/bitstream/handle/20.500.11822/22101/EGR_2017_ES.pdf?sequence=1&isAllowed=y

[3] Peters, G. & Geden, O., 2017: *Catalysing a shift from low to negative carbon.* In: Nature Climate Change, doi:10.1038/nclimate3369

protections are not weakened in a way that is counterproductive to the shared goals of improved environmental stewardship and economic growth.

Direct Air Capture and CO2 Use technology

Exactly one year ago, there were exactly zero commercial projects that separated CO_2 from the air for commercial gain. Today there are three, with additional projects mounting. Several of these were mentioned in my last testimony before this committee,[4] including the Climeworks Direct Air Capture plant in Zurich (Figure 1) and the Regeneration Engine in Reykjavik Iceland. New projects include the Carbon Engineering Air-to-Fuels project in British Columbia, and a US project slated to begin operation this fall, featuring Global Thermostat's DAC technology (Figure 1).

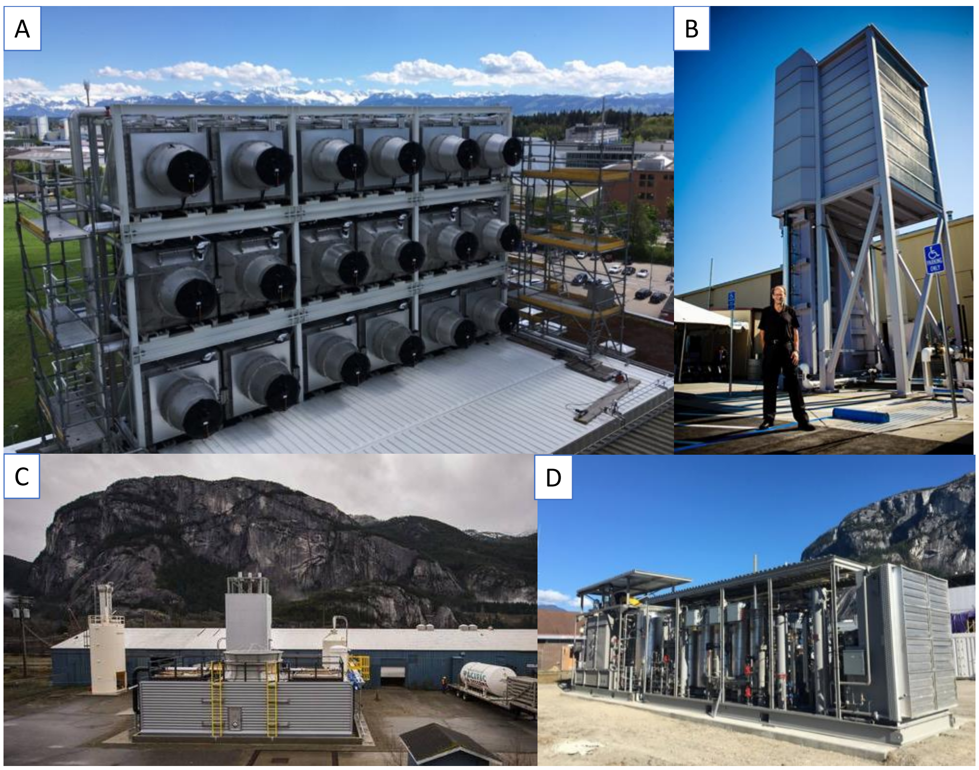

Figure 1: Direct-air capture projects. (A) Climeworks 1000 ton/y project in Hinwil, Switzerland, May 2017 (B) Global Thermostat's pilot plant in Palo Alto, CA, 2014. (C) Carbon Engineering's DAC plant in Squamish, British Columbia 2015. (D) The Greyrock air-to-fuels plant in Squamish at the Carbon Engineering site,

Unlike conventional CO_2 capture, DAC starts with a highly dilute gas stream (400 ppm, or 0.04%. This means that unconventional technologies are needed to separate CO_2 from the air, and that incremental improvements on existing technology will not deliver CO_2 at a competitive price.[5,6] While at the DOE, I was pleased to launch the first solicitation world-wide for capture from streams less than 1% CO_2. However, to make progress in this arena a

[4] https://www.epw.senate.gov/public/_cache/files/e/a/eae08931-a714-434e-84f0-6a2edcebfc0e/BAC13A21C743DCE907756A4A3EFA9C49.friedmann-testimony-09.13.2017.pdf

[5] https://www.aps.org/policy/reports/assessments/upload/dac2011.pdf

[6] http://iopscience.iop.org/article/10.1088/1748-9326/aa6de5/meta

long-lived direct-air capture program with substantial core funding and continued funding is needed. Other countries are getting into the game. Just last year, the UK launched a government program that supports DAC research, as well as other kinds of carbon dioxide removal.[7]

It is reasonable to see DAC in two contexts. First, DAC is an engineered form of pollution clean-up. Based on the Paris Accord, which seeks to achieve "a balance between sources and sinks of greenhouse gases in the second half of this century ", CO_2 removal is required, and DAC is one pathway to achieve that balance. Additionally, it is reasonable to see DAC as a pathway to providing CO_2 to consumers which lack concentrated sources or pipeline infrastructure. Today, these include the food and beverage industry which uses CO_2, but also stranded opportunities for CO_2 storage or EOR, where geological CO_2 storage resources could be used if supplied. In the future, however, customers for DAC-supplied CO_2 will include a new manufacturing and commercial enterprise converting CO_2 to products.

Current and future markets for CO_2-based products include cements and concrete, fuels and chemicals, and solid carbon products like carbon black or carbon nanotubes.[8] Many US companies have started and grown over the past decade in each of these markets, and some will begin to generate revenues this year. This is part of the basis for the NRG/Cosia XPrize in CO_2 capture and use[9] and the basis for the Integrated Test Center in Gillette, WY[10] (and its counterpart in Alberta). Combining DAC with carbon-to-value (C2V) manufacturing can create a distributed manufacturing new carbon economy based on clean power, heat, and CO_2 restored from the air and oceans.[11]

However, many of the key CO_2 conversion and use technologies are at an early stage. The existing DOE programs in this area, both at the Office of Fossil Energy and the Office of Energy Efficiency and Renewable Energy, are relatively small and new. Given the economic and environmental opportunity represented by C2V, additional funding and expanded programs would help achieve important outcomes for economic growth and environmental remediation.

Improving permitting of projects and CO2 infrastructure.

In many ways, the US has demonstrated prowess in fielding and managing CCUS infrastructure. The current network of ~5000 miles of CO_2 pipelines, the class II and class VI statutes at the EPA under the Safe Water Drinking Act, and the long-lived Regional Carbon Sequestration Partnerships program at DOE all exemplify this prowess. However, substantial shortcomings to these programs and infrastructure elements limit the market for greater uptake.

- Most of the CO_2 pipelines were built before 2003. Only a few built since then have crossed state lines. Almost all were built for EOR and do not serve key US saline formation storage resources. Almost all the pipelines are at full capacity.
- Key mid-continent states (IA, IL, IN, OH, WV, PA, and MI) have little or no access to CO_2 pipeline networks.

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[7] https://nerc.ukri.org/press/releases/2017/09-greenhousegas/
[8] http://www.icef-forum.org/platform/upload/CO2U_Roadmap_ICEF2017.pdf
[9] https://carbon.xprize.org
[10] http://www.wyomingitc.org
[11] https://static1.squarespace.com/static/54a2e4c1e4b043bf83114773/t/59cc06aa017db287c38e47d2/1506543286676/New+Carbon+Economy+Consortium+Workshop+Report.pdf

- Many recent CO_2 pipelines were partly financed by the US government for single-point CCUS projects funded by the DOE.
- Only one class VI well (designed for CO_2 storage) has been permitted by the EPA. The process took 54 months. No additional permit proposals are pending.

Many groups have acknowledged that current pipeline infrastructure limits the potential for CCUS deployment in the US today, including the DOE's Quadrennial Energy Review vol. 1.1,[12] the Global CO_2 Initiative,[13] and the State CO_2-EOR Working Group.[14] These groups have recognized a role for governments to support the development of this key environmental infrastructure. They also recognized that improved state and federal coordination would help speed the permitting and development of pipelines and CO_2 storage sites safely and well. Pacific Northwest National Lab estimated that ~10,000-30,000 miles of new pipelines would be needed by 2030 to achieve large-scale deployment of CCUS in the 48 contiguous states.[15]

Often, the permitting, construction, and operational readiness of pipelines and storage sites determines the timeline for commercial projects, and the total project cost is sensitive to the time taken for these steps. Concern about ambiguities in process or delays in permitting directly affect the financial viability of projects and their ability to attract investors – in other words, those concerns are substantial barriers to financing. Policies that would help clarify the timelines, requirements and roles for those involved and limit the burden or risk to potential CCUS project developers will help maximize deployment and minimize waste.

Many other clean energy technologies (such as wind or solar) rightly benefit from policy support for infrastructure and finance risk management. Today, this includes preferred access to existing transmission likes (i.e., loading order or portfolio standards), FAST act support for transmission line permitting, and net metering programs. Programs like DOI's "Smart from the Start" for offshore wind also help, and show how coordinated State and Federal efforts can provide clarity, avoid conflicts among potential stakeholders, and speed permitting.

For CCUS to achieve high deployment rates (50-100M tons/y). more policy clarity, support and program investments are required. For example, the CarbonSAFE program[16] at DOE helps potential project developers and regional interests gather new geological and geophysical data to support new projects in new areas. However, that new data cannot serve to bring projects to market if investors remain confused or concerned about how to build, access, or develop key CCUS infrastructure. Ultimately, additional regulatory clarity, potential streamlining or acceleration of permitting, and additional policy measures will greatly improve the chances of commercial development. Ideally, many stakeholders including industry, state and federal government, NGOs, and public representatives would be involved to seek opportunities to improve current law and statute.

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[12] https://www.energy.gov/policy/downloads/quadrennial-energy-review-first-installment
[13] https://assets.contentful.com/xg0gv1arhdr3/5VPLtRFY3YAIasum6oYkaU/48b0f48e32d6f468d71cd80dbd451a3a/CBPI_Roadmap_Executive_Summary_Nov_2016_web.pdf
[14] http://www.betterenergy.org/wp-content/uploads/2018/02/White_Paper_21st_Century_Infrastructure_CO2_Pipelines_0.pdf
[15] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-17381.pdf
[16] https://www.energy.gov/under-secretary-science-and-energy/articles/energy-department-announces-more-44-million-co2-storage

Final thoughts

We are at the edge of a new carbon economy – one that harnesses innovation and entrepreneurship to create new products, companies, and wealth through capturing and converting fugitive carbon into value-added products. US leadership has already stimulated new interest in expanding CCUS projects, including DAC and C2V projects, but major hurdles still persist that will prevent wider uptake. Those hurdles include insufficient support for domestic innovation in DAC and C2V, and lack of clarity and ease in permitting CO_2 infrastructure in a way that is both economically viable and serves multiple important environmental goals. US companies' competitiveness suffer and are limited in their ability to create export products and technologies in a carbon-constrained global market.

New policies would help create markets for projects, vendors, operators, and energy services in a new carbon economy - ones that can be supported through conventional financial investors that would accelerate the development and deployment of these novel technologies and industries.