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Sept. 18, 2019

Congressional Testimony of
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Before the
Committee on Energy and Commerce
United States House of Representatives
2nd Session, 115th Congress

Chairman Pallone, Ranking Member Walden and Members of the Committee, thank you for inviting me here today to discuss Industrial Decarbonization. My name is Dr. Julio Friedmann. I am a Senior Research Scholar at Columbia University's Center on Global Energy Policy at the School of International and Public Affairs, where I lead an initiative on carbon management. It is an honor, and timely, to appear before this Committee to discuss greenhouse gas emissions from heavy industry.

Since my last congressional testimony in May 2019,[1] the topic of industrial emissions has grown in prominence, in part due to growing public concern over the environmental, economic and social impact of climate change, as evidenced by the Green New Deal and the presidential primary debates. This is long overdue. Global industrial GHG emissions represent about 24% of all GHG emission – more than from all of transportation and almost as much as from power. In the U.S., industry emits 15% of total greenhouse gases, more than all cars. National and global emissions in these sectors are growing fast. To make progress on climate change, it is essential to make rapid progress in decarbonizing industry.

Heavy industry, including the manufacturing of steel, cement, refining, petrochemicals, fertilizer, and glass, is essential to the U.S. economy and national security. Industry is a major employer (notably for organized labor and underserved communities across the nation, and could be jeopardized by international border tariffs based on carbon content. In many cases, margins are very tight for these sectors, and (unlike for power or transportation fuels), international competition is fierce.

Industrial emissions are highly localized in large central facilities in a few states, notably Texas, Louisiana, Oklahoma, New Jersey, California, and along the Great Lakes. These facilities are important sources of local pride, high-paying jobs, thriving communities, and state revenues. They undergird other key sectors like automobile manufacturing and construction, and are the focus of

[1] https://energypolicy.columbia.edu/research/testimony/enhancing-future-ccus

questions regarding environmental justice and equity. To maintain global commercial competitiveness and serve our communities in many ways, we must understand what is possible and discuss what is effective and fair in the context of climate change and energy transition.

The bad news is that progress on industrial emissions is extremely difficult. We have very few options and our current options are expensive due to the very nature of industrial physics, chemistry, engineering, and markets. There are potential new pathways, yet these are underdeveloped due to chronic underinvestment and many uncertainties face the companies and policy makers in considering viable options. The good news is that there are things to do that are likely to prove cheap, effective, impactful, and low-risk. Swift action could provide both commercial and competitive advantages for the U.S., and if done well, could reduce both criteria pollution and greenhouse gas emissions with little impact to customers.

The challenges to managing industrial emissions are both difficult and straightforward:

- **No substitutes**: There are few viable substitutes for many commercial industrial products – cement, steel, glass, paper, and plastics. We use more of these materials every day both in the U.S. and the world and attempts at reducing consumption have not been successful.
- **Long-lived critical assets**: Cement kilns, blast furnaces, ammonia plants, and refineries are multibillion-dollar assets. They operate today making money for their owners, are pretty efficient, and serve key manufacturing chains and stakeholders (including cities, the military, the Army Corps, etc.). Some facilities have just been upgraded and most anticipate long operational lives. This makes it unlikely that they'll be replaced soon.
- **Few options**: Even if we could replace major industrial facilities, it's unclear what would serve to both produce critical products with minimal emissions. Primary steel and cement production have byproduct chemical emissions from coking and clinker production – we lack technology options that don't emit. Similarly, most of these options require very high temperature heat – glass, steel, and cement production basically melt rocks as their first step – for which we lack alternatives to fossil fuels. Electrification of many of these systems is not possible as a retrofit and is very challenging or speculative as a new facility.

Thankfully, a number of groups and scholars, including at Columbia University, are diving into this sector. In part we do so, following President Kennedy's words, because it is hard and because it is required. My own work focuses both on industrial heat and on other pathways to industrial decarbonization, which I chose for that reason.

The good news is that the community of scholars and experts agree to the findings of what actions would be most effective:

- **CCUS is essential**: Analysis from the Intergovernmental Panel on Climate Change and dozens of other organizations conclude that carbon capture, use, and storage (CCUS) is essential to achieve important climate targets, including 2°C, let alone 1.5°.[2] Without CCUS most models do not converge on a solution at all. Those that do cost more than twice as much to reach the same targets. This is largely due to the role CCUS can play in heavy industry.[3] It is the ***only*** technology known today that can capture process emissions from cement[4]. It is the first, cheapest, largest fraction of what can be deployed in the U.S. and globally.[5] It is the fastest, cheapest pathway to low-carbon hydrogen and can help enable other key approaches like biofuels and renewable hydrogen. It is also the lowest cost for mitigation available today and will drop further in price through deployment. I spoke to this in some detail during my Senate testimony last May, which may be found at this link (https://energypolicy.columbia.edu/research/testimony/enhancing-future-ccus).
- **Hydrogen is promising**: To provide high-quality heat on demand, low-carbon hydrogen is the first, best option for many industries. This is especially true for industries that use natural gas, such as refining and petrochemicals, which can readily exchange one gaseous fuel for a new one with only modest retrofits and costs. Overall, hydrogen appears to provide minimal disruption to existing operating assets and could quickly and substantially reduce GHG emissions. The lowest cost low-carbon hydrogen options today involve steam methane reforming plus CCUS. As the costs for renewable electricity and electroyzers drop, renewable "green" hydrogen can begin to substitute for fossil-based low-carbon hydrogen.
- **Innovation investments are essential**: Most of the other options (e.g., biomass based or electrical based approaches) are not yet mature. The U.S. has underinvested in advanced technology options for heavy industry, including ways to deeply reduce carbon pollution. Today, the U.S. essentially supports no programs and no funding for such work. A new innovation focus on clean heavy industry would help maintain a muscular U.S. heavy industry, help us remain globally competitive, and could prove the cornerstone for future

[2] IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, 32 pp. https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf

[3] Global CCS Institute, 2018, Global Status of CCS Report: https://www.globalccsinstitute.com/resources/global-status-report/

[4] Energy Transition Commission, 2018, Mission Possible: Reaching near-zero emissions from harder-to-abate sectors by mid-century: **www.energy-transitions.org**

[5] IEA 2018b, The future of petrochemicals: Towards more sustainable plastics and fertilizers (full report), https://www.iea.org/petrochemicals/

infrastructure and jobs investments.[6] Doing so would also reduce conventional pollution, improving the quality of life for those living near such facilities and strengthening our national commitment to environmental justice.[7] There are several bills pending now, including the EFFECT act[8] and the Clean Industrial Technology Act (CITA)[9] which would stimulate RD&D for industrial applications.

Given what's at stake and what's required, it's clear we need to start now on this difficult set of challenges. Thankfully, there are straightforward policies and actions that Congress can undertake today with either near- or long-term impact.

- *Procurement Standards*: Unlike in the power sector, Federal, State and City governments directly or indirectly buy enormous fractions and volumes of industrial products - for example, roughly 90% of cement and concrete, 50% of steel and 5% of fuels[10]. This gives government procurement enormous leverage in these markets. A well-designed national zero-emissions 'buy clean' standard would immediately create demand for low-carbon industrial products and stimulate private investment in decarbonizing industrial sources. Importantly, analysis suggests that even substantial wholesale increased in the costs of primary industrial products (like cement and steel) would have almost no effect on the final price of finished goods (like bridges and cars) – in many cases only a 1% difference in final costs.[11] Governments also need to develop procurement and performance standards to advise companies the specific technical requirements needed to obtain an offtake contract. Recent state legislative proposals and new laws provide a model for how this might be enacted.[12]

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[6] Energy Futures Initiative, 2019, Advancing the Landscape of Clean Energy Innovation, https://energyfuturesinitiative.org/news/2019/2/6/clean-energy-innovation-report
[7] Mckinsey, 2018, Decarbonization of the industrial sector: the next frontier. https://www.mckinsey.com/industries/oil-and-gas/our-insights/decarbonization-of-industrial-sectors-the-next-frontier
[8] US Senate, 2019, S. 1201, https://www.congress.gov/bill/116th-congress/senate-bill/1201/text
[9] US House, 2019, H. 4230, https://www.congress.gov/bill/116th-congress/house-bill/4230?q=%7B%22search%22%3A%5B%22clean+industrial+technologies%22%5D%7D&s=3&r=1
[10] Dell R., in press, Pathways to Deep Decarbonization
[11] Op Cit.
[12] CA Legislature, 2017, public contract code amendment 3500-3505 https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?division=2.&chapter=3.&part=1.&lawCode=PCC&article=5. And https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act

- *Infrastructure*: Whether for CCUS, hydrogen, or electrification, it is likely that more public infrastructure would accelerate adoption. For example, almost all CCUS is accomplished through the 5000 miles of shared CO_2 pipelines. Deployment of conventional CCUS will require thousands of miles more, mostly in the form of small regional networks that serve communities and regions while storing in local, high-quality geological storage sites.[13] Similarly, additional high-voltage DC and/or AC transmission to heavy industry or hydrogen infrastructure would serve to reduce costs and operational obstacles to adoption (Appendix A & B). Laws such as the USE IT Act, currently under consideration, could reduce risk and ambiguity for CO_2 and hydrogen pipelines and make financing and operation easier. Additional incentives, such as block grants to states or regions, a competitive grant program managed by the Office of Fossil Energy, or a bespoke investment tax credit, could help greatly.
- *Innovation agenda:* It appears that power sector decarbonization will be faster and easier that industrial systems, in part because there are options available. This is in part follows over 50 years of R&D and government procurement for renewables, advanced nuclear, and natural gas production. Given the challenges facing industrial decarbonization, we must invest now in developing alternatives that could be fielded in the future. This will help maintain U.S. competitive in the complex global markets and support innovators in small companies and universities across the country. Such work is essential in early deployment, and is a good complement to other policies like tax incentives and carbon pricing that might follow in the future.[14]

These policies have the advantage of being fairly cheap, serving multiple interests, and delivering change quickly. In contrast, many other conventional climate policies may prove less effective in industry than in other sectors (like power). For example, an economy-wider carbon tax may prove helpful but insufficient to drive industrial decarbonization, in part because of the lack of technical options and in part due to the high current cost of direct management of greenhouse gas emissions in these sectors. Moreover, the trade implications for industrials like steel and petrochemicals might prompt protectionist approaches like a border carbon adjustment. While that might prove effective, the potential consequences could be negative and enormous to trade, international partnerships, and domestic industries broadly. That's why I have two final recommendations:

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[13] Great Plains Institute, 2017, 21st Century Energy Infrastructure: Policy recommendations for development of American CO2 pipeline networks, 27p,. https://www.betterenergy.org/wp-content/uploads/2018/02/GPI_Whitepaper_21st_Century_Infrastructure_CO2_Pipelines.pdf

[14] Sivaram V. & Kaufman N, 2019, The next generation of federal electricity tax credits., CGEP report, https://energypolicy.columbia.edu/research/commentary/next-generation-federal-clean-electricity-tax-credits

- Analysis: While other countries have Ministries of Industry, the U.S. does not have a Department of Industry. There is no government agency tasked with aggregating all the relevant data on fuel use, emissions, commercial production, health effects, and trade for industry that would advise either the Executive or Legislative branches. To be clear, I am not proposing the creation of a new agency or department. Rather, agencies, like DOE, EPA, Transportation, and Commerce and entities like NIST, the Export/Import Bank, and others share aspects of the U.S. industrial enterprise. They require better understanding of the current state of affairs and the likely costs and timelines of current and future options. Congress should consider how and where best to create such an analytical authority that can bridge and serve these agencies and provide it with access to the funding and data required to inform them well (for example, vesting the job of analysis and data gathering at the DOE in partnership with other agencies). Some of these provisions are mentioned in the draft CITA language.
- Internationally coordinated sector agreements: Trade concerns inhibit investment and action in reducing industrial emissions, in large part due to concern about disadvantaging domestic industries in a global market. One way to manage these concerns is to coordinate international activity and agreements in specific sectors (e.g., chemicals, steel, aluminum). International discussions and agreements could be modeled after the Montreal Protocol, with specific caps and reduction targets and timelines agreed to by all key parties and with growing ambition over time.

In summary, we have little choice. To remain globally sustainable and globally competitive, it's essential to start the work of industrial decarbonization in a way that respect the limits of physic and chemistry, the needs of communities and industries, and the urgency of the challenge. With that, I look forward to your comments and questions.