BEFORE THE SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

HEARING TO EXAMINE S. 383, THE UTILIZING SIGNIFICANT EMISSIONS WITH INNOVATIVE TECHNOLOGIES ACT, AND THE STATE OF CURRENT TECHNOLOGIES THAT REDUCE, CAPTURE, AND USE CARBON DIOXIDE

TESTIMONY OF KURT WALTZER
ON BEHALF OF THE CLEAN AIR TASK FORCE
FEBRUARY 27TH, 2019

Chairman Barrasso and ranking member Carper, thank you for the opportunity to testify today. My name is Kurt Waltzer and I am the Managing Director of the Clean Air Task Force. The Clean Air Task Force is an environmental non-profit dedicated to catalyzing the development and global deployment of low-carbon energy technologies, and other climate protective technologies, through research, public advocacy leadership, and partnerships with the private sector.

I am here today to voice CATF's support of the USE IT Act. The development and deployment of technologies such as carbon capture utilization and storage and direct air capture carbon is critical to avoiding the worst impacts of climate change. If enacted, the USE IT Act will support innovation in the areas of direct air capture and CO2 utilization, while also helping to facilitate infrastructure development that would benefit all forms of carbon capture. Policies such as these are urgently needed to develop the robust technology tool kit that we need to address climate change.

The Scale and Urgency of the Climate and Technology Challenge

The size of the climate challenge is staggering. Global energy and industrial production releases over 37 billion tonnes per year of CO_2. These emissions come from diverse sources in the power, industrial, transportation, commercial, and residential sectors. Increasingly, the emissions come from developing countries as well as developed ones.

To prevent the worst impacts of climate change, not only must these emissions be eliminated by late this century, but there must also be actions that result in negative emissions (i.e., more greenhouse gases sequestered than are emitted).[i] Based on current projections, average temperature growth is estimated to reach between 4.1 degrees and 4.9 degrees Celsius above pre-industrial conditions, unless action is taken to reduce emissions. Humanity has never existed in a world where the estimated global temperature is above 2 degrees more than pre-industrial conditions. In order to achieve less than 2 degrees C of global warming, worldwide manmade CO_2 emissions must be at least 50–80% lower in 2050 relative to 2010. [ii] In order to achieve less than 1.5 degrees C of warming, at least a 65–90% reduction in CO2 is needed from 2010 levels by 2050[iii]. Moreover, we know these emission reductions are going to have to occur in a global economy where total energy demand is projected to increase 40% between 2010 and 2040.[iv]

Unfortunately, global emissions are in fact going in the wrong direction. Since nations first agreed to establish the U.N. Framework Convention on Climate Change, in 1992, global CO_2 emissions have increased 66%[v]. Whether this trajectory can be altered depends on policy, investment and innovation. The world's need for economic development, energy and mobility cannot be denied. But the climate challenge demands this need be met through energy sources with much lower carbon emissions than conventional technologies.

Currently, coal, oil and gas energy sources, that are unbated for CO_2 emissions, dominate the world's primary energy production – providing over 81%. In terms of low-carbon sources, nuclear energy provides roughly 4% of the world's energy, with wind and solar providing less than 1% of global energy production. Carbon capture, utilization and storage has only been recently applied to energy production with fossil sources through a few commercial demonstration projects.

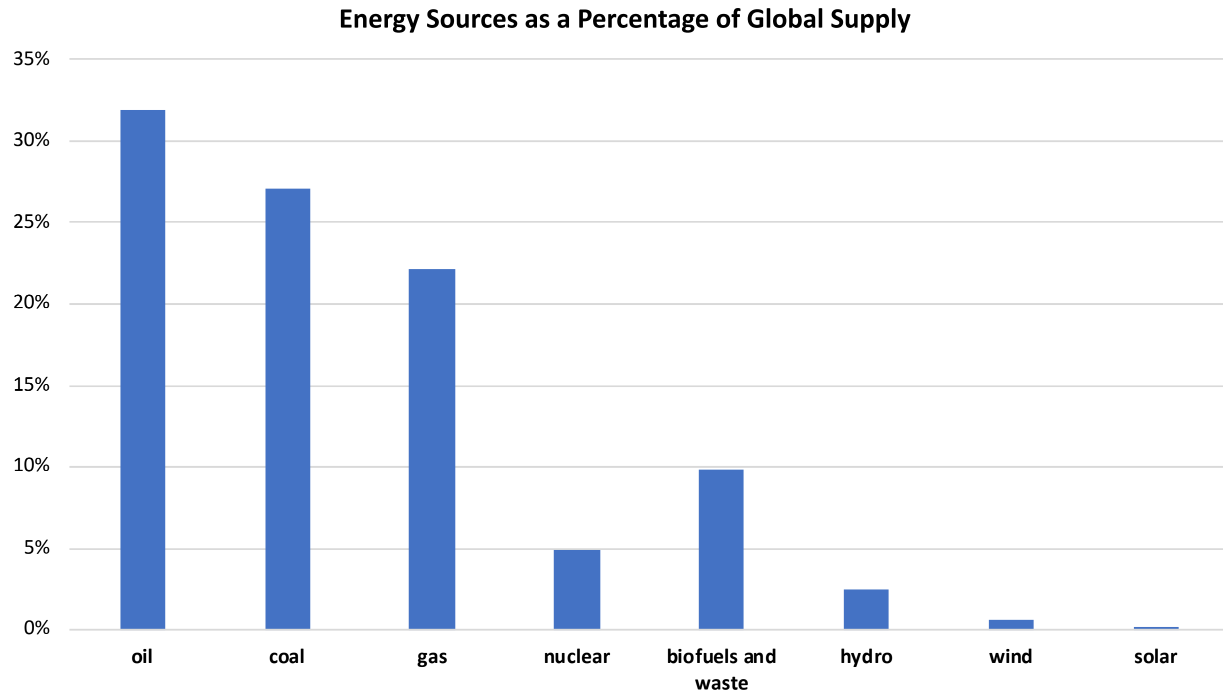

Figure 1 Source: International Energy Agency, Key Energy Statistics, 2018 (2016 data)

Moreover, the current global energy system represents $25 trillion of investment, with an annual energy investment on the order of $1.8 trillion per year, and that rate is expected to grow as demand increases. Existing energy capital stock has a turnover rate of 2% to 4% per year.

Given the scale and urgency of this challenge, replacing or modifying the system will require global markets to prefer zero-carbon technology over carbon-intensive alternatives for both new and replacement infrastructure. Meeting this challenge may be possible, but only if we ensure there are widely commercially available low-carbon technologies that global energy markets will deploy in the system.

The Need for a Low-Carbon Technology Portfolio

To maximize our chance of meeting this challenge within our limited window of time, we need a broad tool kit of technologies and policies. Our technology tool kit will require the continued development and deployment of technologies such as advanced renewable energy, nuclear fission and fusion, CCUS, low-carbon fuels, and electrification, where possible, in the transportation and industrial sectors.

Given the substantial, rapid emission reductions needed, as well as the challenges of energy asset turnover and capital availability, it is clear that the need for action is urgent. In order to minimize the risk of failing to prevent climate change, most decarbonization modeling suggests we need to develop multiple zero-carbon technology options. This is the case for two reasons:

(1) *Having a portfolio reduces risk of any one technology failing.* Technology innovation and market behavior are unpredictable, so relying on any single technology or a narrow group of technologies risks failure. A simple thought experiment based on portfolio theory supports a diversified approach; if 10 different technologies each have a 50% chance of failure, there is only a 0.1% chance they will all fail, as shown in Figure 3. While this is an oversimplification, the reality is we cannot predict the final level at which any potential option will be taken up in our future energy system – at least with enough accuracy to be confident we are adequately addressing the decarbonization challenge. All options will have inherent limits, and a diversity of solutions increases the likelihood of success.

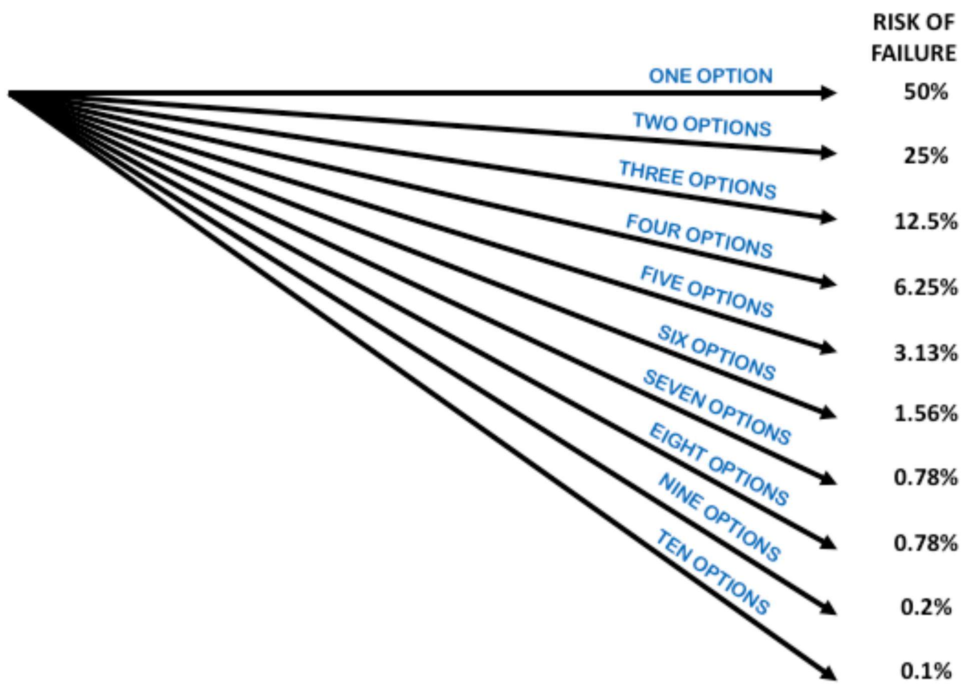

Figure 2 Source: Clean Air Task Force

(2) *Greenhouse gas emissions come from a wide range of activities, so we need a range of low-carbon solutions*. In the transportation sector, for example, we need solutions for many different purposes (personal, public and freight transportation) and modes (e.g., planes, trains, buses and automobiles). In the power sector, because supply and demand options vary over

space and time, we need a mix of resources to accommodate a range of temporal, geographic, and climatic conditions. We also need innovation at the power system level to integrate a mix of supply and demand technologies into a resilient whole.

Some of these activity areas are particularly challenging. These include industrial sources for which CO_2 emissions are an inherent part of the process (such as steel and cement), and types of transportation that are not easily electrified (such as shipping, long-haul trucking, and aircraft).

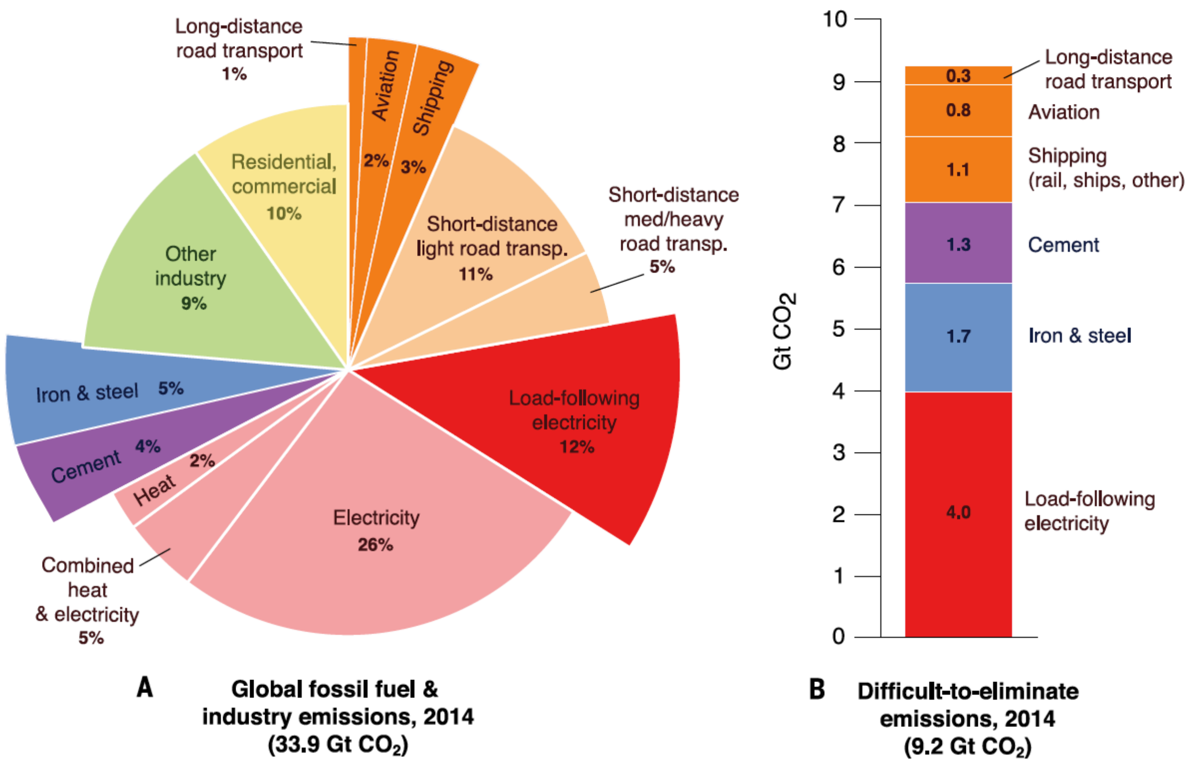

Figure 3 Source: Davis et al., Science 360, 1419 (2018) 29 June 2018

Load-following electricity is also a significant challenge. Low carbon variable energy sources, such as wind and solar, are likely to play in important role in decarbonizing power grids. However, relying *only* on these resources can be substantially more expensive due to the need to overbuild generation and energy storage facilities in order to meet full demand load. One recent study looking at Texas and New England power markets found such systems could be as much as 105% (Texas) and 163% (New England) more expansive than a system using a more balanced portfolio that also included nuclear, gas with carbon capture and storage and bioenergy[vi].

The Importance of Carbon Capture in the Technology Portfolio

Carbon capture utilization and storage can play an important role across many of the "hard to reach" areas of our energy sector. CCUS has been best understood as a source of potential dispatchable or load-following electricity, including the notable demonstration projects of NRG's Petra Nova and Sask Power's Boundary Dam, as well as the technology pilot project of NETPower. In addition, CCUS is an important technology for emissions reduction from industrial sources. While it can be applied across a range of industries, it will be particularly important for industrial sources with CO_2 process emissions, such as steel and cement production[vii]. CCUS can also be applied to the production of zero-carbon fuels such as hydrogen or ammonia. This approach is currently under development in the Netherlands and Japan[viii].

More broadly, carbon capture, utilization and storage, and direct air capture will play a crucial role in decarbonizing our global energy system. In the Intergovernmental Panel on Climate Change's (IPCC's) 4th assessment report, the vast majority of decarbonization scenarios that limited global temperature growth to 2 decrees C from pre-industrial conditions include the use of CCUS (Figure 3)[ix].

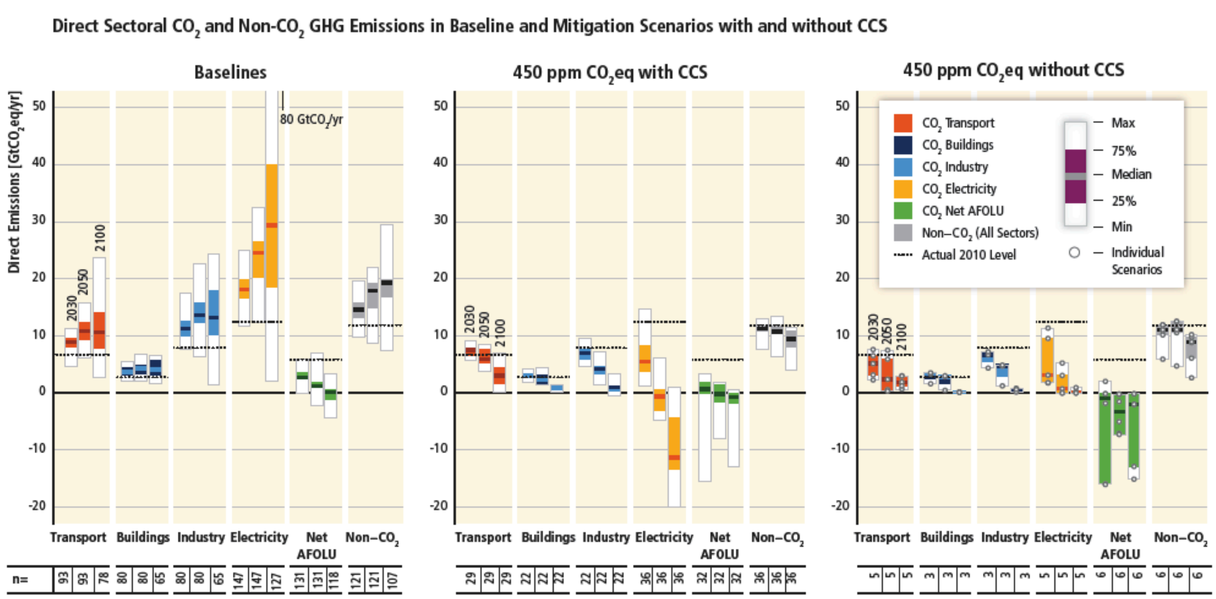

Figure 4 Direct emissions of CO_2 by sector and total non-CO_2 GHGs (Kyoto gases) across sectors in baseline (left panel) and mitigation scenarios that reach around 450 (430 – 480) ppm CO_2eq with CCUS (middle panel) and without CCUS (right panel). The numbers at the bottom of the graphs refer to the number of scenarios included in the range which differs across sectors and time due to different sectoral resolution and time horizon of models. Note that many models cannot reach about 450 ppm CO_2eq concentration by 2100 in the absence of CCUS, resulting in a low number of scenarios for the right panel.

Source: IPCC, 2014: Summary for Policymakers. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*

In the IPCC's recent report on limiting temperature growth to 1.5 degrees C, three different scenarios projected a need of between 348 billion tonnes to 1,218 billion tonnes of CO_2 to be captured and stored by the year 2100. The share of carbon removal ranged from 43% to 97%, depending on the level of energy growth through the century. The only scenario where carbon capture and sequestration technologies were not included at significant levels, included a dramatic *reduction* in global energy demand of 32% between 2010 and 2050[x]. Relying on such a demand reduction to address climate is highly risky, given the history of demand growth to date and the likely growth, particularly in developing economies, which is projected to be 40% between the years 2010 and 2040[xi].

The Need for Comprehensive Policy

Given the scale and scope of change that is required, we must use all the policy tools available to us to accelerate change. Our tool kit must include policies that promote R&D, and leverage private sector investment in demonstration, deployment and infrastructure development. In addition, we need to provide a clear signal to inventors and investors that our energy system of the future will be zero-carbon through either emissions requirements, technology requirements or carbon prices.

There are important examples of how innovation and requirements can work in combination to reduce technology costs and drive technology deployment.

One of the most arguably successful public health benefits in terms of air quality improvement has been the deployment of pollution controls on coal-fired power plants. The health impacts from fine particle pollution from coal-fired power plants have dropped substantially, with estimated premature mortality dropping 90% between the years 2000 and 2014[xii]. In large part this is due to the deployment of pollution controls such as sulfur dioxide scrubbers – with most coal-fired generation in the US coming from units that have installed sulfur dioxide scrubbers[xiii]. This result was driven by a combination of initial R&D investment paired with requirements through the Clean Air Act, which helped catalyze a technology cost reduction of scrubbers by nearly 50% from 1972 and 1996[xiv], and paved the way for broad scale deployment through subsequent rules and regulations.

Another example can be seen through deployment of photovoltaic solar technology. Historically, early R&D investment combined with deployment incentives (such as the investment tax credit) and requirements (such as state portfolio standards), have helped drive technology deployment and cost reduction. The combination of the R&D, deployment incentives, and market requirements have helped drop technology costs from $104/W in 1976 to $0.67/W in 2014[xv].

It should be noted, however, in both cases most of the cost reduction came through incremental, not transformative technology innovation. Absent continued support for technology advancement, deployment incentives and requirements can lead to technology lock-in[xvi], where cost reductions are driven more by learning than transformational innovation.

Given the scale of the climate and technology challenge we are facing, we will need a robust approach to innovation that drives transformational technologies that are cost competitive with carbon-intensive alternatives, can deploy rapidly, can easily access the low-cost equity and debt from financial markets, and can either adapt to or facilitate change of infrastructure and regulatory frameworks. Catalyzing the development of multiple low-carbon technology options will require policy tools that drive:

- investment in transformative R&D
- development of commercial demonstration projects from first of a kind (FOAK) projects to Nth of a kind project (NOAK)
- initial deployment in energy market
- development of supporting infrastructure and regulations

The USE IT Act is an important component to the set of tools needed to help carbon capture and storage, and direct air capture meet reach wide scale availability.

The Importance of the USE IT Act

As technologies, carbon capture and storage and direct air capture are both old and new. Carbon dioxide capture and its injection into geologic strata have been in commercial use for decades, and direct air capture technologies are a direct result of the US military's decades-long interest in developing novel fuel source alternatives. Both technologies are now being repurposed to address our climate crisis. Both technologies will need access to secure geologic storage sites and both will benefit from the development of a robust CO_2 pipeline network. Both will also benefit from further developing markets that utilize CO_2 in products, including enhanced oil recovery, but also other end uses, such as aggregates for construction material, specialty chemicals, plastics and other items.

One key difference is that while carbon capture for industrial and power sources is seeing continuing investment into next generation technology, direct air capture is undergoing first generation innovation. That makes it even more important to support direct air capture at this point in the process, including with the types of policies that are included in the USE IT Act.

This bill is an important follow-up to the recent enactment by Congress of the FUTURE Act, that extended and expanded the 45Q tax incentive for carbon capture and storage and direct air capture. 45Q has the potential to catalyze a broader market for these technologies. CATF recently released a study on the potential impact of the 45Q provision, *Carbon Capture & Storage in the US Power Sector: The Impact of 45Q Financial Tax Credits*[xvii]. The study found that the provision has the economic potential to drive 49 million tonnes of emissions reduction per year in the power sector by 2030 – the equivalent of taking 7 million cars off the road. It is important to note that this is only an economic potential, and to ensure it can be met, other factors will need to be addressed - including the development of CO_2 pipeline infrastructure.

It’s also important to recognize as well, that like the FUTURE Act, this bill represents a bi-partisan commitment to support innovation. CATF greatly appreciates this broad support for such policies and in particular the approach stated by Senator Barrasso to approach any future amendments to this bill on a consensus basis with all of the bill’s co-sponsors.

As noted above, while not sufficient by themselves, policies that promote innovation and infrastructure development are important for decarbonizing our energy system. The USE IT Act addresses the need for innovation and infrastructure by promoting direct air capture and utilization technologies, while also helping to facilitate the development of CO_2 projects and pipelines.

Establishing a prize competition for direct air capture is an innovative method for drawing technologies into the next stage of development. Such prizes have had powerful impacts, such as the Orteig prize that prompted Charles Lindberg’s crossing of the Atlantic. As with the early stages of air travel, private companies are investing in this area to develop initial commercial technologies, and as while the development of intercontinental air travel took substantially more policy and investment, the prize played an important catalytic role. At least three commercial companies have developed direct air capture technologies and rewarding them for meeting a performance target would provide important support at this time.

Carbon dioxide utilization, aside from enhanced oil recovery (EOR), is also in the early stages of development. Like direct air capture, it is an area attracting new investment. Accelerating the development of new end uses that ensure carbon dioxide is removed from the atmosphere with a robust R&D program will provide important support for this emerging industry. And while the market for other products may not be as large as for EOR, they can play an important catalytic role in moving carbon capture technology forward. As an example, Carbon Clean Solutions developed its first carbon capture project in India, producing baking soda from CO2 capture at a coal-fired power plant. The company is building on that experience by developing its next generation of solvents to further lower carbon capture costs – which would benefit all forms of CCUS.

In terms of infrastructure development, the US has an important foundation for development in that we have 4,500 miles of CO_2 pipelines in place. However, for carbon capture and storage and direct air capture to be deployed at scale, we will need a pipeline network several times that size. A 2009 study by the Interstate Natural Gas Association of America (INGAA) Foundation estimated a substantial use of carbon capture technology would require up to 66,000 miles of CO_2 pipelines[xviii]. The current CO_2 pipeline network is primarily point-to-point delivery, whereas we will need larger interstate trunk pipelines as well as pipeline spurs that helps make the buying and selling of CO_2 less financially risky through a more robust commodities market, in much the way that the natural gas delivery market functions today. By clarifying that CO_2 pipelines are eligible under the FAST Act and creating regional task forces focused on facilitating better and more efficient coordination on the permitting of interstate CO_2 pipelines, the USE IT Act would provide an important step in building this needed network, while maintaining the environmental protections that are needed to ensure responsible development.

In summary, the enactment of the USE IT Act would be an important step on carbon capture utilization and storage and direct air capture innovation and infrastructure development and is another important example of pragmatic bipartisan policy. I appreciate the opportunity to testify this morning and look forward to answering your questions.

---

[i] The Intergovernmental Panel on Climate Change (IPCC) concludes that greenhouse gas emissions must be reduced by 40 to 70% by 2050 and must be zero or below in 2100. Cuts from the electricity sector must be even deeper. The IPCC concludes that electricity sector emissions must reach zero by 2050 and be negative by 2100. (See pages 20 and 28 of the Synthesis Report Summary for Policymakers, available at: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf) The International Energy Agency (IEA) reaches a similar conclusion: a 50% reduction in CO2 emissions from the whole energy sector is needed by 2050, while "the power sector becomes virtually decarbonized." (See page 107 of Energy Technology Perspectives, available at: https://www.iea.org/publications/freepublications/publication/etp2010.pdf).

[ii] IPCC, 2014: Summary for Policymakers. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[iii] 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, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. P.rtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. P.an, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

[iv] International Energy Agency. World Energy Outlook, 2018

[v] Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). Global, Regional, and National Fossil-Fuel CO2Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2017

[vi] Sepulveda, Jenkins, de Sisternes, and Lester, "The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation" Joule 2, 2403–2420, November 21, 2018

[vii] IEA (2017), *Energy Technology Perspectives 2017: Catalysing Energy Technology Transformations*, IEA, Paris, https://doi.org/10.1787/energy_tech-2017-en.

[viii] https://www.equinor.com/en/news/evaluating-conversion-natural-gas-hydrogen.html ; https://hydrogenenergysupplychain.com

[ix] IPCC, 2014: Summary for Policymakers. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[x] 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, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. P.rtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. P.an, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

[xi] International Energy Agency. World Energy Outlook, 2018

[xii] https://www.catf.us/educational/coal-plant-pollution/

[xiii] https://www.catf.us/educational/coal-plant-pollution/

[xiv] Taylor, Rubin, and Houndshell, "Regulation as the Mother of Innovation: The Case of SO^2 Control", LAW & POLICY, Vol. 27, No. 2, April 2005; Yubin, Yeh and Houndshell, "Experience curves for power plant emission control technologies:, Int. J. Energy Technology and Policy, Vol. 2, Nos. 1/2, 2004

[xv] Trancik, J.E., Brown, P.R., Jean, J., Kavlak, G., Klemun, M.M., Edwards, M.R., McNerney, J., Miotti, M., Mueller, J.M., Needell, Z.A., 2015. Technology Improvement and Emissions Reductions as Mutually Reinforcing Efforts: Observations from the Global Development of Solar and Wind Energy. Technical Report. Institute for Data, Systems, and Society, MIT. http://energy.mit.edu/publication/technology-improvement-and-emissions-reductions-as-mutually-reinforcing-efforts/

[xvi] J. Hoppmann et al. "The two faces of market support—How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry", Research Policy 42 (2013) 989– 1003

[xvii] https://www.catf.us/2019/02/ccs-reduce-49-million-tonnes-co2-emissions/

[xviii] https://www.ingaa.org/File.aspx?id=8228&v=4903b99e