

OPPORTUNITIES IN INDUSTRIAL DECARBONIZATION: DELIVERING BENEFITS
FOR THE ECONOMY AND THE CLIMATE

Wednesday, November 15, 2023

United States Senate

Committee on Environment and Public Works

Washington, D.C.

The committee met, pursuant to notice, at 10:01 a.m. in room 406, Dirksen Senate Office Building, the Honorable Thomas R. Carper [chairman of the committee] presiding.

Present: Senators Carper, Whitehouse, Merkley, Markey, Padilla, Fetterman, Capito, Cramer, Ricketts, and Sullivan.

STATEMENT OF THE HONORABLE THOMAS R. CARPER, A UNITED STATES
SENATOR FROM THE STATE OF DELAWARE

Senator Carper. I am more than pleased, I am delighted to call this hearing to order. Senator Capito will testify I do not often say I am delighted to be chairing the hearing, but today I am. This is great stuff and we are grateful to our witnesses who are here, grateful to Senator Capito and her team, and the folks on our staff as well.

Today's hearing is focused on the next frontier of tackling climate change, decarbonizing the industrial sector of our economy. Our hearing is timely, as some of you may know.

Yesterday, the Biden Administration issued the Fifth National Climate Assessment, which underscored the urgency of addressing climate change and the benefits of doing so. The report found that, on average, adjusting for inflation, in the 1980s, the United States experienced a \$1 billion disaster every four months. Today, there is one every three weeks.

The report also found that if we are going to limit the increase of global warming to 1.5 degrees Celsius, which is our goal, our Country must reach net-zero greenhouse gas emissions by 2050.

Why should we focus on reducing industrial emissions? To answer that question, let me begin by sharing an age-old story of Willie Sutton. I have told this story once or twice in this

room. Many of you will recall, he was a notorious bank robber during the Great Depression. He robbed a lot of banks and finally got caught and ended up in front of the judge who said to him, "Mr. Sutton, why do you rob banks?" He replied, "Your Honor, that is where the money is." I think that is a story actually worth retelling today. Willie Sutton's logic can actually apply to all of us as well.

Heavy industry makes products that are central to our lives, including steel, cement, and aluminum. At the same time, the industrial sector is responsible for nearly one-third of global greenhouse gas emissions and represents the third largest source of U.S. emissions, trailing only the transportation and power sectors.

By 2030, the industrial sector is expected to become the largest source of domestic greenhouse gas emissions. I will say that again. By 2030, seven years from now, the industrial sector is expected to become the largest source of domestic greenhouse gas emissions.

As many of us know, there are real challenges when it comes to decarbonizing the industrial sector. For example, because of the diverse industrial processes we use to make a variety of goods and materials, there isn't a simple one-size-fits-all approach. Instead, we must deploy a variety of different technologies and process changes.

Yet, within these challenges also lies real opportunities. In addition to helping us meet our climate goals, reducing industrial emissions presents great opportunities for us to invest in, among other things, American industry in order to boost our Nation's economic competitiveness.

The benefits of decarbonizing key industrial materials go beyond simply mitigating emissions at individual facilities. By producing materials in cleaner ways, we can reduce emissions throughout supply chains. By investing in the industries that are producing lower carbon materials for our buildings, our roads, and our electric vehicles, we can help support our clean energy transition.

Fortunately, when it comes to decarbonizing the industrial sector of our economy, we are already making progress. That is thanks in no small part to the investments that Congress made in the Bipartisan Infrastructure Law and the Inflation Reduction Act, measures that were written, in no small part, right here in this room.

For example, our Bipartisan Infrastructure Law established the new Office of Clean Energy Demonstrations at the Department of Energy, which included a new Industrial Demonstrations Program. Last Congress, Congress provided \$6.3 billion in funding to this program to help deploy technologies to reduce industrial emissions.

The Bipartisan Infrastructure Law also included \$8 billion for the development of regional clean hydrogen hubs throughout our Country. I was especially pleased that the Department of Energy awarded funding to the Mid-Atlantic Clean Hydrogen Hub project which includes parts of Delaware, Pennsylvania, and New Jersey. Our hub was one of seven clean hydrogen hubs, including the Appalachian Hydrogen Hub which included the States of West Virginia, Ohio, and Pennsylvania.

These clean hydrogen hubs will provide a reliable supply of clean hydrogen for transportation, industrial processes, and power generation across our Nation. They will create tens of thousands of good-paying jobs in our regions. Let me repeat that. They will create tens of thousands of good-paying jobs in our regions across the Country.

As the largest purchaser of materials in the world, the Federal Government also has a great opportunity to foster demand for low-embodied carbon materials through federal procurement. We can and we are.

In our committee's title of the Inflation Reduction Act, we provided over \$5 billion for the Federal Highway Administration and the General Services Administration to buy materials such as concrete and steel for buildings, roads, and bridges made with low carbon emissions. We also included funding for the EPA to help us better understand the lifecycle greenhouse gas emissions

of various construction materials and products. Supporting America's ingenuity and innovators is key to creating cleaner goods here at home, and we will hear from our witnesses about that today.

In closing, the United States can continue to manufacture steel, aluminum, concrete, and other materials while reducing greenhouse gas emissions. By doing so, we can make American industry more competitive on the global stage while addressing climate pollution and creating a lot of good-paying jobs.

To do this, we need collaboration across sectors and stakeholders. Industry leaders, innovative start-ups, government agencies, environmental organizations, and academia must all work together. And so must we. I think we actually do that pretty well here.

My hope is that today's hearing will help us further our committee's understanding of some of the challenges and opportunities associated with decarbonizing heavy industry. We look forward to hearing from our panel of knowledgeable witnesses and to having a productive and spirited discussion today.

Before we do that, I want to recognize our Ranking Member, Senator Capito, for her good work on this front. I am happy to work with her and her team. Senator Capito, you are recognized.

[The prepared statement of Senator Carper follows:]

STATEMENT OF THE HONORABLE SHELLEY MOORE CAPITO, A UNITED STATES
SENATOR FROM THE STATE OF WEST VIRGINIA

Senator Capito. Thank you, Mr. Chairman.

I apologize in advance. I have something going on that is causing my voice to disappear. A Senator's voice disappearing is a dangerous thing.

Anyway, Senator Carper, thank you for holding this hearing today to examine innovative, bipartisan solutions to manage industrial greenhouse gas emissions. We have achieved the greatest success, I think, as a committee, including on climate, which we have worked on in a bipartisan way.

The Committee's Surface Transportation and Water Infrastructure legislation served as the backbone of the IIJA. The surface transportation portion of the IIJA included a first-of-a-kind subtitle devoted to climate change featuring two new formula programs, one for carbon, one centered on carbon reduction and on resiliency.

The IIJA served as a vehicle for many provisions from other committees to address emissions, including industrial emissions. Chairman Carper and I managed that legislation across the Floor and so we negotiated many of these positions as well.

Particularly important to me, and the Chairman mentioned this in his statement, the legislation included the Regional Clean Hydrogen Hubs Program administered by the DOE. As you

mentioned, one of the seven hubs the DOE recently selected is the Appalachian Regional Clean Hydrogen Hub, known as ARCH2. This hub includes the States of West Virginia, Ohio, and Pennsylvania.

ARCH2 will produce both green hydrogen, which is hydrogen produced through the electrolysis of water, but also blue hydrogen, which is hydrogen produced from abundant Appalachian natural gas with carbon capture and storage technologies to reduce emissions. When up and running, ARCH2 will supply hydrogen to a broad mix of hard-to-decarbonize industries, from energy to transportation to chemical manufacturing to steel production.

It is no secret that carbon capture, which will be a critical component of the ARCH2 hub, remains capital intensive and has yet to be commercially viable for deployment.

Chairman Carper, I really appreciate your years-long partnership with me in supporting carbon capture as a technology. This is why I have been a longtime supporter of 45Q to advance this technology that will be essential in preventing emissions, and through direct air capture, to reduce atmospheric concentrations of carbon dioxide.

ARCH2 and all other future CCUS developments stand to benefit not only from 45Q, but also from prior legislation out of this Committee, such as the USE IT Act, which Chairman

Carper, Senators Barrasso, Whitehouse and I led. Signed into law in 2020, the USE IT Act, when implemented as intended, would ensure all carbon capture projects at all types of facilities can be permitted in a timely fashion.

I said "when implemented as intended" because some of the Administration's recent actions suggest they are not dutifully looking to expedite the permitting of these types of projects. For instance, for broad deployment of CCUS to become feasible, the EPA must approve Class VI injection well applications to securely store the carbon underground. I believe your State is one of only two that have been able to do this on a State basis.

In the IIJA, I supported the inclusion of \$50 million for States to obtain primacy of this program, as well as \$25 million for the EPA to process those permits at the Federal level. The EPA needs the help because it has historically only approved two of these permits, and it took an average of six years each to do this.

The IIJA was signed into law two years ago today, November 15, 2021, and only last week did the EPA finally announce the money for States to apply for primacy. In addition to delaying the application process for funding, the Administration has now loaded up the primacy application process with new guidance and directions to address environmental justice that seems designed to slow projects down or suggest they are not safe. Meanwhile,

the EPA has not permitted any of the 169 well applications that are now pending.

Instead of focusing on expediting permitting and environmental reviews, the President's Council on Environmental Quality has focused on changing the rules of the road for the NEPA process. The Administration's recent proposal, instead of simplifying the environmental review and permitting process as Congress directed in the recent debt limit legislation, would add hurdles to these processes and expand the scope of reviews, opening projects up to increased delays and legal challenges.

I do not want to suggest hydrogen and CCUS are our only tools for reducing industrial emissions, but I think we need to take note of the regulatory headwinds we are facing. I support other bipartisan solutions to reducing industrial emissions, such as utilizing advanced nuclear for industrial purposes. My bipartisan nuclear bill with the Chairman, the ADVANCE Act, includes a number of important policies to deploy advanced nuclear to do just that.

No matter how good the bipartisan solutions this committee and others enact to address climate change are, our efforts will never be realized if the projects they support are never built due to permitting challenges and a slew of new EPA regulations. Regulations such as the forthcoming Particulate Matter 2.5 National Ambient Air Quality Standards, NAAQS, that the

Administration is rumored to plan finalizing at a level that will plunge much of the Country into nonattainment, requiring stricter permitting or offsets for new infrastructure or industrial facilities.

Regulations such as the Clean Power Plan 2.0 will undermine reliability and drive up the cost of power for manufacturing with its unachievable short-term targets. Antiquated regulations like the New Source Review will stymie upgrades at existing power plants and manufacturing facilities. The list goes on and on.

I urge my colleagues to continue to work with me on permitting reform and updating outdated environmental regulations, areas within this Committee's jurisdiction, so we can ensure that emissions-reducing technologies can actually get out into the market and make a difference.

Thank you to all of the witness here today and I look forward to our discussion and learning more about your efforts to reduce carbon emissions.

[The prepared statement of Senator Capito follows:]

Senator Carper. Senator Capito, thank you. I thought you sounded great. If Kevin and I end up coming down with this tomorrow, I will know where it came from.

Senator Capito. I don't want to ruin anyone's holiday.

Senator Carper. Hopefully, you will be better really soon.

As you know, we all serve on a number of different committees. In some cases, those committees are meeting right now. One I serve on is going to have a markup and I need to be there to vote. In a little bit I will slip out and go vote. I have to go out to a place called the swamp for a few minutes before that for a quick presser. In the meantime I appreciate that Senator Capito keeping the trains on schedule. I have had a chance to read your testimonies and hopefully, I will have a chance to hear most of it before you finish.

Now I want to turn to our esteemed panel of witnesses. We are grateful to two of you for joining us today in person. I understand one of the witnesses is also under the weather, maybe with COVID or something. We hope she will be feeling better soon.

First, we are going to hear from Dr. Abigail Regitsky, the Senior Manager, U.S. Policy and Advocacy Team at Breakthrough Energy, a network of investment funds, non-profits and philanthropic programs and policy efforts, working together to scale the technologies that are needed to achieve net-zero

emissions by 2050. In this role, Dr. Regitsky is responsible for implementing Breakthrough Energy's climate policy priorities with a focus on industrial decarbonization and innovation.

She earned her Ph.D. in Material Sciences and Engineering from the Massachusetts Institute of Technology, MIT, and brings a wealth of knowledge of industrial de-carbonization. Our oldest son is a graduate of MIT. I could barely spell MIT when I was at Ohio State. Fortunately, we have sons who are a lot smarter than me.

Our second witness is Dr. Leah Ellis, CEO and Co-Founder of Sublime Systems, Inc., a Massachusetts-based company, beginning to commercialize a breakthrough low carbon cement manufacturing process. Dr. Ellis, how do you pronounce the university in Canada you went to?

Ms. Ellis. Dalhousie.

Senator Carper. She started Sublime Systems with a colleague at MIT during her tenure as a post-doc fellow there. To date, Sublime Systems has begun to scale their technology that eliminates the need for fossil fuels in cement production. I am interested in hearing more about that.

Third, we will hear from Ms. Shannon Angielski, President of the Clean Hydrogen Future Coalition. When my wife asks me, what did you do today, I will say I met with the President and she will be impressed.

She is President of the Clean Hydrogen Future Coalition, a diverse group of stakeholders to promote clean hydrogen as a critical pathway for decarbonization.

Ms. Angielski has spent her career developing and advocating for clean energy and carbon management policies with a particular focus on hydrogen as well as carbon capture utilization and sequestration.

We thank you again for appearing before the committee today. We will now begin our witness testimony.

We will lead off with Dr. Regitsky. Please proceed with your statement when you are ready.

STATEMENT OF ABIGAIL REGITSKY, SENIOR MANAGER, U.S. POLICY AND
ADVOCACY, BREAKTHROUGH ENERGY

Ms. Regitsky. Chairman Carper, Ranking Member Capito, and members of the committee, thank you for the opportunity to appear before you today.

I am honored to represent Breakthrough Energy, a network founded by Bill Gates to scale the technologies we need to reach net-zero emissions by 2050. Following eight years of work, we just published our first State of the Transition Report to share the progress being made and the challenges that remain ahead.

Innovation is at the heart of Breakthrough Energy's mission, and more than any other sector, industry cannot decarbonize without innovation. The industrial sector is responsible for transforming raw materials into the products of our daily lives, like the cement in our buildings and bridges and the steel in our cars and appliances. It has been the engine of American economic development.

It also accounts for nearly a fourth of U.S. greenhouse gas emissions and about one-third of global emissions. While sectors like power and transport are expected to continue reducing emissions, industrial emissions are expected to stay flat and could even increase, likely making it the top source of U.S. emissions in the future.

In part, the slow progress comes from industry's reputation

of being hard to abate. This is largely because the main sources of emissions are essential to how industrial goods are manufactured today, namely emissions from industrial heat and process emissions from chemical reactions.

For example, steel making requires temperatures over 2000 degrees Celsius. The raw material for cement contains CO₂ that is released when it is made.

The good news is that many U.S. companies are actively working on breakthrough technologies to address these emissions, as well as reduce and eliminate air, land and water pollutants. This will bring tangible health and quality of life benefits for the workers in industrial factories and the fence-line communities surrounding them.

Several solutions are cross-cutting and can be applied in many sectors. These include energy and material efficiency, electrification, the use of hydrogen and other low carbon fuels and feedstocks and carbon management. One promising example is thermal energy storage, which stores renewable energy as heat and then delivers this heat for use in industry.

For every cross-cutting area, building enabling infrastructure, like more transmission, will be critical, as is robust community engagement on the risks and benefits of each technology. In addition to cross-cutting technologies, each sector can benefit from tailored solutions. For example, one

company is developing a fully electric process that reduces iron ore and makes steel in one step. While promising, many of these technologies are relatively immature and for those close to market readiness, barriers still remain, such as high capital costs, long factory lifetime, low profit margins, and competition from other countries.

Smart policies that address the entire innovation cycle from R&D to deployment will be critical to accelerating the path to market. Policies must support the supply of clean industrial technologies through investments in RD&D and financial incentives. Congress recognized this in passing the Clean Industrial Technology Act, introduced by Senator Whitehouse and Ranking Member Capito as part of the Energy Act of 2020. Then through the Infrastructure Bill and the Inflation Reduction Act, Congress provided a historic \$6.3 billion for industrial demonstration projects.

Industry applied for nearly ten times the program's budget, indicating the need for future funding. Complementary public procurement or buy-clean policies can create sizable markets for low emissions goods. The IRA included over \$5 billion for federal procurement of low carbon construction materials. It is critical that these programs target materials with the lowest possible embodied emissions available today.

Furthermore, new policies will be needed to provide long

term offtake such as through advance market commitments or contracts for difference, which will unlock further investments. To maximize these domestic investments, climate aligned trade policies must address potential emissions leakage.

As a first step, policies must build the data infrastructure to reliably measure and report embodied carbon which underpins the effective design of all the above policies. Fortunately, Congress is increasingly paying bipartisan attention to these issues.

For example, Senators Coons, Cramer and several members of this committee introduced the PROVE IT Act. On average, U.S. industry already boasts lower emissions intensity production internationally and decarbonization investments will only strengthen this carbon advantage and increase global market share. Others are also developing trade policies to address carbon leakage and competitiveness. This includes Senator Whitehouse's Clean Competition Act and Senators Cassidy's and Graham's Foreign Pollution Fee Act.

Breakthrough Energy supports bipartisan discussions to develop trade policy that bolsters the competitiveness of domestic industries and puts a spotlight on manufacturing emissions abroad to incentivize industrial decarbonization around the world.

Addressing industrial emissions will also safeguard

manufacturing's role as a critical piece of the U.S. economy. This year, the manufacturing sector employed 13 million Americans. For every one manufacturing worker, 4.4 workers are added to the economy overall. Thus, investing in this sector will pay dividends in economic growth and revitalize communities that have suffered decades of progressive deindustrialization.

In summary, without intervention, the industrial sector is set to become the highest emitting U.S. sector in the next decade. Addressing industrial emissions depends on a full spectrum approach of supply side investments, demand side market creation, trade policies and data infrastructure.

Decarbonizing industry not only aids net zero goals but enhances American competitiveness, retains and creates manufacturing jobs and benefits worker and community health.

The world is on the brink of a clean industrial revolution, and America is poised to take the lead. I urge the members of this committee and Congress to not let this opportunity pass us by.

The prepared statement of Ms. Regitsky follows:]

Senator Capito. [Presiding.] Thank you. Thank you very much.

Now we will hear from Dr. Ellis.

STATEMENT OF LEAH ELLIS, CEO AND CO-FOUNDER, SUBLIME SYSTEMS, INC.

Ms. Ellis. Chairman Carper, Ranking Member, Capito and members of the committee, thank you for hosting today to discuss the important role the Federal Government plays in accelerating low carbon building materials.

I am the CEO of Sublime Systems, a company commercializing low carbon cement. I am here to talk to you about the extraordinary opportunities enabled by industrial decarbonization. These include fostering innovation, attracting talent, creating jobs, boosting domestic manufacturing, and fighting global climate change. This is a win-win that energizes myself and my colleagues, as well as my peers, in many adjacent industries.

Today's cement manufacturing is responsible for 8 percent of global CO2 emissions. If the industry were a country, it would be the third largest emitter after China and the U.S.

Today's cement is made in massive fossil fuel kilns running at temperatures up to 1,400 degrees Celsius to cook limestone, which releases CO2 as it decomposes in the kiln. I started Sublime Systems with the mission of having a swift and massive impact in reducing these emissions.

At Sublime, we use electrochemistry instead of heat to turn non-carbonate minerals into cement. Our process runs at room

temperature and entirely on electricity. This avoids both the limestone and the fossil fuel emissions that I mentioned before.

Our cement is fully compliant with industry accepted performance-based standards and we can produce over 100 tons of cement per year in our pilot facility, which we are scaling quickly.

The public sector has a unique ability to accelerate cement's decarbonization. Collectively, it deploys 60 percent of all the cement used in America through the building of public infrastructure. You have admirably responded to this challenge in several ways, many of which we can't fit into my allotted five minutes, but I will highlight a few.

Sublime has received Department of Energy ARPA-E funding which enabled us to de-risk our technology as it spun out of the university, which allowed us to attract venture capital investment. Secondly, both the General Services Administration and the Federal Highway Administration have recently allotted billions to the use of low carbon construction materials. Sublime has already noticed increasing customer interest in response to these policies and we urge Congress to consider making such initiatives permanent.

We have collaborated with other low carbon cement developers to encourage further policy adoption. The Decarbonize Cement and Concrete Alliance is focused on

procurement policy, demand support measures and early adopter platforms, as well as another critical lever, production tax credits.

The existing 45Q tax credit rewards technologies that capture carbon, but it does not reward technologies such as ours that avoid CO2 emissions in the first place. We encourage technology-agnostic implementation of tax credits to create a level playing field for all industrial technologies that avoid CO2 emissions and address climate change.

I would like to acknowledge the DOE's Office of Clean Energy Demonstrations, OCED, as a vital initiative for helping technologies create products at scale and unleash the transformational job opportunities in the process. Sublime is currently engaged with OCED for potential funding of our first commercial facility, and we are confident in our prospects.

However, if we are ultimately not selected, we believe this will primarily reflect how many quality innovations are seeking this money. I urge Congress to make this program permanent and to generously fund it until the American economy is decarbonized.

Decarbonizing industry offers an opportunity to spur an American manufacturing revival, especially in communities that have been left behind. We have used the Justice40 screening tool and policy tools to identify the location of our first

commercial plant, a western Massachusetts site in a disadvantaged community census tract. This city formerly housed a booming paper industry. We are already collaborating with city officials, community organizers, non-profits and unions to ensure that our plant delivers maximum benefits to residents.

We have signed a strategic partnership focused on high quality jobs with United Steelworkers, and we are exploring a collaboration with the Smithsonian Science Education Center. We expect to create 70 benefits-bearing jobs, and many of these roles will not require an advanced degree, making them accessible to those who have not gone to college.

We know that the clean energy transition can be a just transition. It can also be a prosperous one, bringing an industrial boom, the likes of which we have not seen in hundreds of years.

The fact that you are hosting this hearing today is already quite impactful in highlighting the climate and economic opportunities within. I thank you for your work in this and for your time today, and we look forward to your continued partnership.

Thank you.

The prepared statement of Ms. Ellis follows:]

Senator Capito. Thank you.

Ms. Angielski.

STATEMENT OF SHANNON ANGIELSKI, PRESIDENT, CLEAN HYDROGEN FUTURE COALITION

Ms. Angielski. Thank you, Ranking Member Capito, also to the Chairman and members of the committee for this opportunity to discuss the role that clean hydrogen can play in industrial decarbonization.

As the President of the Clean Hydrogen Future Coalition, I represent a diverse set of stakeholders that came together to promote clean hydrogen as a critical pathway to achieve global decarbonization objectives. Our foundational principle is to decarbonize the economy through technology neutral and resource agnostic, or, as we call it, color-blind policy, that will enable clean hydrogen to be a scalable decarbonization solution.

Obviously, we know the international climate authorities have identified clean hydrogen as a pathway for meeting global climate targets, and that is really because clean hydrogen is a game changer. It has the ability to accelerate decarbonization across all sectors as well as transition existing and create new skilled, high-paying jobs that underpin the clean energy transition.

There is a thriving hydrogen market today that operates. It is mainly used in petroleum refining and ammonia production, which represents approximately 90 percent of total domestic hydrogen production in use. Other hydrogen applications are

used in smaller quantities for synthetic fuels, chemicals and plastics or other niche applications. However, we currently produce hydrogen almost totally from natural gas, and that is because we have low cost, abundant supplies that supported by a vast network of infrastructure.

As Senator Capito already pointed out, there are alternative methods to lower the carbon intensity of these hydrogen production methods such as electrolytic hydrogen using zero emitting electricity, as well as reforming of fossil fuels with carbon capture and storage.

If the domestic refining industry were to convert their existing production methods to produce clean hydrogen, that process in and of itself would reduce industrial sector greenhouse gas emissions by 5.5 percent. That is really not an insignificant number, particularly after what Leah has already said. There are other industries that do not currently use hydrogen, as already has been mentioned, steel, concrete and others, so we have several ways to decarbonize those industries using clean hydrogen.

I really want to thank Congress for the work that has already been done, both bipartisan and through the IRA. Many of these programs Senator Capito already mentioned, and the witnesses, so I will not talk about the hydrogen hubs, which are critical at this point, as well as the Section 45E tax credits

and the industrial decarbonization funding. But there has also been other legislation introduced by Senators Coons and Cornyn that I want to raise that would enable clean hydrogen to decarbonize the industrial sector and port operations.

In the last Congress, Representatives Tonko and McKinley introduced a bill that would establish a pilot program at DOE to enter into contracts for differences to offset what are the increased costs associated with the production or purchase of clean hydrogen in industrial applications.

The Coalition is also recommending that Congress consider funding a new program in the farm bill. This would provide grants for the production and use of ammonia that is produced with clean hydrogen as a feedstock for domestic fertilizer production and as a tool to lower, obviously, greenhouse gas emissions in the industrial sector. There are a couple of hydrogen hubs that are looking at that sector to provide their clean hydrogen to offset those fertilizer production methods.

While groundbreaking and necessary investments made by Congress will serve as a significant down payment to expand the clean hydrogen economy, it is important to recognize that additional policies will be needed to achieve economies of scale and stimulate the use of clean hydrogen, particularly in those industries where hydrogen is not currently used as the incumbent fuel or feedstock.

DOE suggests that securing long term off-take agreements for clean hydrogen is one of the key near-term challenges, as well as the associated infrastructure buildout. The long term off-take agreement is really due to the significant cost gap between the cost of clean hydrogen and the incumbent fuels, which are much cheaper, as I have already mentioned, as well as the volumes of hydrogen that are needed to decarbonize these industrial processes.

DOE has also indicated that in order to achieve their goal of 50 million tons of clean hydrogen per year by 2050, the entire clean hydrogen supply chain must scale rapidly. That will only occur if new policy is adopted that incentivizes the private sector investments that are needed.

There is precedent for Congress to enact policy support to stimulate the creation of new markets when it deems it is necessary to do so. Clearly the existing domestic clean hydrogen market will need similar policy treatment. We look forward to working with Congress to develop and design some of those new demand use policies that will enable capital creation.

As the Administration considers how to implement an indirect booking claim accounting system for implementing the 45E tax credit, the Coalition wants to caution against adopting principles such as additionality or hourly time matching as those measures would delay investment and make clean hydrogen

unnecessarily costly.

The Coalition is pleased that Chairman Carper, along with Senator Cantwell and ten of her Senate Democratic colleagues, submitted letters to the Administration urging against adopting overly prescriptive regulations that would make the use of the 45E tax credits largely inaccessible, and have the negative impact of little private sector investment, and really delay the ability of clean hydrogen to be an industrial decarbonization tool.

I want to conclude my remarks by sharing the significant benefits that have already been discussed through industrial decarbonization and that clean hydrogen can bring. It can bring a lot of benefits to communities across the Country in jobs, as well as health impacts and reduction in environmental emissions, and creating a new clean hydrogen commodity market carries significant economic value and positions the U.S. to be a global leader in the export of hydrogen.

Thank you again and we appreciate the opportunity to be here.

The prepared statement of Ms. Angielski follows:]

Senator Capito. Thank you. Thank you, all three of you.

We are going to go to Senator Markey first.

Senator Markey. Thank you, Madam Chair.

Environmental justice cannot be an afterthought of industrial decarbonization. It must be front of mind. For far too long fence-line and frontline communities have borne the brunt of industrial pollution, wreaking havoc on the health and economic wellness of Black, Brown and low wealth individuals in our Country, and creating environmental sacrifice zones in the name of economic growth for others.

When it comes to industrial innovation, we need to be better than before, not continuing with business as usual, which created the climate crisis and environmental injustices. That is why industrial decarbonization that depends on green hydrogen needs guardrails and strong standards.

Ms. Angielski, will you commit to advocating for the three guardrails of green hydrogen, additionality, deliverability and hourly time matching, to help us deliver the greenest hydrogen possible?

Ms. Angielski. Thank you for the question and I recognize the issues that you are raising, Senator.

The Coalition is proposing that we adopt more restrictive policies, as you are suggesting, these three guardrails of additionality, restrictive or hourly matching, and regional

matching over time. Our recommendation is to begin to adopt more restrictive measures beginning in 2030, which is a similar approach to what the European Union has adopted.

The reason for that is we want to see significant investments in the supply chain that is necessary to support the scale of that industry and the growth of the industry in order for clean hydrogen to deliver on that decarbonization solution for industrial decarbonization.

Senator Markey. I would say that I am just going to urge you to understand that we want your ambitions to be high for innovation, but we also want ambitions to be high to ensure that we are not perpetuating injustice and obscuring pollution, which is what these industries have done historically.

That is a long time frame and that is why guardrails for hydrogen created with targeted new and renewable energy, as well as continuous inclusive community engagement, will be what spurs truly clean energy technologies.

Dr. Ellis, thank you for joining us from Somerville, Massachusetts. You said in your testimony that Sublime Systems tried to keep community needs in mind when selecting the site of its first commercial plant in the Commonwealth, including using tools like the Climate and Economic Justice Screening tool, which is based on my Environmental Justice Mapping and Data Collection Act.

Dr. Ellis, do you agree that it is important for deployed clean tech solutions to provide strong benefits to the surrounding communities through a transparent and robust community benefits agreement process?

Ms. Ellis. Thank you, Senator Markey.

I agree. I believe that the energy transition can be a just transition.

In the case of Sublime Systems, we have used the Justice40 Tool to look at where we might site our first commercial plant. What struck me is that many of these disadvantaged communities are the site of old manufacturing towns. In fact, what makes these towns, what makes them left behind and disadvantaged is the same reason why new manufacturing will come to these towns. These are places where permitting is already sighted industrial. There is already access to railroads. In many cases, these sites already have access to hydroelectricity that has been built decades and even hundreds of years ago.

We believe that coming back to the city is right for us, but it is also right for the community. We hope to bring not only jobs and training, but also to really integrate with the community and be a good neighbor to the people who are welcoming us into their community.

Senator Markey. Thank you. As you said, after China and the United States, cement is third in terms of emissions. It is

responsible for 8 percent of all global carbon emissions. Even once new technologies get developed to try to tackle that problem, it can take two decades for the market to catch up.

How can the Federal Government further drive demand for low carbon construction materials like cement?

Ms. Ellis. Thank you, Senator Markey. The U.S. Government buys 60 percent of the cement that consumed in the United States.

Senator Markey. Say that again. That is a crazy number.

Ms. Ellis. It is, in fact, a crazy number. The U.S. Government buys 60 percent of the cement in the United States, and that is a combination of the GSA, the Federal Highway Administration, the Army, DOT, both at the State and Federal level.

If there are no advance market commitments, if there is no commitment to buy low carbon cement from the Government, this makes my job, as an innovator in this sector, more than twice as difficult as it should be. I believe the Government has a responsibility to make these commitments to create bankable contracts that will allow us to get project finance to build these plants.

Moreover, that 8 percent of global CO2 emissions, it is not mostly in the United States. It is global. These countries that are going to be building more because of growing and

urbanizing populations, are undergoing a period of dirty growth. They are going to be building cement plants that are based on legacy fossil fuel technology unless we can move quickly to develop American-made electrochemical technology, deploy this internationally and export our technologies.

Senator Markey. So the faster we innovate, and that can be driven by robust federal procurement policies, because the Federal Government consumes 60 percent of all cement. Then we can export that new technology that gets developed because the Federal Government had strong procurement policies around the rest of the world.

I thank you. I know my time has expired. Thank you, Madam Chair.

Senator Capito. Senator Cramer.

Senator Cramer. Thank you, Madam Chair.

Thanks to all of our witnesses for being here. I will try not to jump around too terribly much. So much has already been said that is intriguing to me.

I want to start with you, Ms. Regitsky. your testimony referred to the United States' comparative carbon advantage. I appreciate that terminology. It also points out appropriately that the United States imported more than 1.2 gigatons of embodied emissions, mostly from China.

I appreciate, Dr. Ellis, your referencing this is a global

issue. We tend to look inward and sort of beat ourselves up a little bit, in my view, too much. By the way, I love the idea of being the innovators and then exporting the innovation. We sometimes forget that most of what we export is brainpower and innovation as well as products.

That said, according to data that was compiled by the CRC, goods manufactured in the United States are 40 percent more carbon efficient than the world's average. But the U.S. imports 75 percent of its goods from less carbon efficient countries.

Again, getting back to this global issue, getting back to trade policy as much as anything, is why I often say that so much of our energy and environmental policy is inward. It is punitive, rather than recognizing the global nature of all of this.

I want to get to the PROVE IT Act, that is where I am leading. I appreciated Ms. Regitsky bringing it up, because without good solid data to demonstrate the statistics I just used, I don't know that we can move forward as easily until we start proving that we really are more carbon efficient than the rest of the world.

We have actually done a lot to bring down CO2 emissions in the United States. We really have been innovative. Rather than buying more steel from China, how about more steel from West Virginia, or Indiana or how about proving that a Bakken barrel

of oil is cleaner than a Venezuelan barrel of oil? In the cement sector, especially, this probably is as obvious as it is anywhere.

I am not saying we shouldn't always strive to improve. It is not that. I think we beat ourselves up too much. What is my point? I guess I would just like, Ms. Regitsky, if you would talk a little bit more about the PROVE IT Act and what value that could bring to the discussion.

I might ask you, Dr. Ellis and Ms. Angielski, on the same topic of data collection, while we try to forward lean into the production. Ms. Regitsky?

Ms. Regitsky. Thank you, Senator Cramer, for the question and for your bipartisan introduction of the PROVE IT Act.

As you have mentioned already and I mentioned in my testimony, data is really kind of the first piece of the puzzle to start, as you said, proving that indeed much of U.S. production is already more emissions efficient than other countries, especially countries that we are importing our goods from.

What the data allows us to really have this transparent reporting of this emissions intensity and the competitive advantage, the carbon advantage, of U.S. production. The other thing it enables us to do is respond to when other countries are starting to think about their own policies. For example, the

EU, as you probably know, is starting to implement their own carbon border adjustment mechanism.

By folks looking at the existing carbon advantage of the U.S., such as CLC, they noted that because of the U.S.'s carbon advantage, looking at the U.S. imports into Europe, into the EU, versus, say, China's imports to the EU, which are going to be more carbon intensive, the U.S. actually stands to gain market share in the EU market with the EUC ban in place.

Having things like PROVE IT will enable us to make sure that when those types of policies that other countries put in place come into fruition, we can really make sure that they are fair and are accurately representing the low emissions intensity of the U.S. market.

Senator Cramer. Very well said. Dr. Ellis, anything more?

Ms. Ellis. Yes, I would like to echo that. The Europe Carbon Border Adjustment Rule is very important for protecting against dirty imports.

I would also say that in the EU and in America, there is a proliferation of EPDs, environmental product declarations. That is the nutritional label for cement materials that list not only the embodied carbon of that material, but also the embodied energy. Many of the other pollutants that Senator Markey mentioned affect the local communities in which these materials are made.

Ms. Angielski. I can speak to you with respect to clean hydrogen. Right now, the lifecycle analysis and accounting methodology is already built into Federal policy to qualify for clean hydrogen, whether it is tax credits or DOE grant funding. That accounting system for tracking the emissions associated with production and use is already built into Federal policy that will catalyze this industry.

It is really important to recognize that if there are industries that want to use clean hydrogen and that will purchase it at a premium price, for example, the carbon intensity value of that hydrogen is going to be the critical aspect of that. Because there are industries that are going to want to be able to say, look, I am using decarbonized hydrogen and it is reducing my product emissions by X amount. That is the selling point and the value add, I will just say for clean hydrogen.

Senator Cramer. This looks to me like the PROVE IT Act is at is sort of the low-hanging fruit in this group.

Ms. Angielski, I wanted to ask you, of course, about the Heartland Hydrogen Hub. Thank you for your work on that.

Thank you, Madam Chair.

Senator Capito. Thank you. Senator Whitehouse.

Senator Whitehouse. [Presiding.] Thank you. Thanks to Senator Cramer for his interest in carbon border work and I look

forward to making more progress in that area.

Dr. Regitsky, we have a number of things on the horizon. The first is the European Union's CBAM, Carbon Border Adjustment Mechanism, which will begin counting carbon emissions shortly and begin tariffing carbon emissions in 2026. The United Kingdom, it has just been reported, will be joining the EU on a similar schedule with a similar carbon border tariff to neutralize any tariff obligations between the UK and the European Union.

What effect will that have on decarbonizing America's industrial sector?

Ms. Regitsky. Thank you, Senator Whitehouse, for the question and the opportunity to build on my response to Senator Cramer's question as well.

Yes, the new CBAM policies that the EU and the UK are planning to put in place, already in motion, will certainly have an impact globally and on U.S. manufacturing as well. As we have already been discussing, U.S. manufacturers are often already much more carbon efficient and energy efficient than manufacturers in other countries. So they stand to gain actually from being able to access more of these European and UK markets because they have a carbon advantage to some of the other countries that are importing into those places.

If we couple that with further investments in

decarbonization in our domestic industry, then that carbon advantage is just going to keep growing and growing and creating even more opportunity to take that global market share. As other countries beyond the European continent are thinking about border adjustments as well, then that just furthers the opportunity even more.

Senator Whitehouse. The economic experts who advised the EU and the CBAM note that there will be some economic headwinds for America by virtue of having to pay a carbon tariff to the EU, because we are more carbon intensive than the EU, but that that headwind will be more than offset by a massive tailwind as manufacturing now taking place in China and supply chains now beginning in China move to the United States because the relative difference between the tariff that China would have to pay and the tariff that the U.S. would have to pay would actually be a huge economic value.

If we were to step up our own participation in the EU and now potentially UK CBAM, we could reduce the tariff headwind while also enjoying the tailwind. Is that not correct?

Ms. Regitsky. Yes, that is exactly right, Senator.

Senator Whitehouse. Then one other thing that I would mention that is coming at us is the Administration's decision, the Office of Management and Budget's decision, which I very strongly applaud, to take the social cost of carbon that is

shortly to emerge from the Environmental Protection Agency's, EPA rulemaking process and make sure that it is applied across the board. We have heard testimony about buying cement. Into that cement calculation would now have to fit \$190 per ton social cost of carbon.

I expect, Dr. Regitsky, that you also see that as a positive influence on industrial decarbonization in America?

Ms. Regitsky. Certainly, having some kind of mechanism to differentiate the emissions intensity of the products that the Federal Government is buying will be able to advantage those who are producing the more efficient product, as well as create those markets for innovators like Sublime and others to really see the potential of the market for the investments that they are making into their net zero technologies. It will certainly be able to increase the amount of innovation in really being able to get to net zero in industry.

Senator Whitehouse. It is a fairly elementary proposition of market economics that polluters should pay the cost of their pollution rather than socialize the costs of their pollution onto other innocent parties. Without that, the whole principle of market economics, which is the principle of price signals, is warped and degraded and doesn't work any longer.

Do you believe it is consistent with traditional economic policies to have the social cost of carbon and the CBAM, and

other tariffs reflect the fact that there are harms from carbon emissions?

Ms. Regitsky. I would say that I am certainly not an economist, but my understanding is generally being able to price in these negative externalities where the costs are being brought on to somewhere in society and putting those in the places that are causing the actual harm and the cost does align with the idea of negative externalities in economics.

Senator Whitehouse. You may not be an economist, but you know what negative externalities are. That is a pretty good first step. I will take it.

Thank you, Chairman.

Senator Capito. [Presiding.] Thank you.

Ms. Angielski, in my opening statement, I talked about ARCH2, the Hydrogen Hub, and how excited we are to have that coming to our region, particularly my State. But each hub has selected different mixes of pathways for producing, and I think that was written into the bill.

When it comes to build-out of our Nation's hydrogen infrastructure, where do you think the initial demand will come from and what will the associated emission benefits be?

Ms. Angielski. Thank you, Senator Capito.

I am familiar with the hub in West Virginia and the ARCH2 hub. The important attribute, I would say, about the hydrogen

hubs generally is that they will enhance that sort of network effect that is needed by aggregating both the production, the transport and use demand, and enable that infrastructure to be shared, and the lower cost, at least initially, as the industry grows.

One significant benefit of what the ARCH2 hub is looking at is that they have a variety of end use sectors that exist within the hub that can take advantage of it. If you think about the existing markets, those are probably the lowest hanging fruit in terms of emissions reductions and targets where hydrogen can be adopted in those sectors. That is because they already need hydrogen and use hydrogen.

But the other sectors as in the industrial, for plastics, chemicals, whether we are talking about transportation fuels outside of the industrial sector, or even in other industrial end uses like cement or concrete, that is where hydrogen can grow and expand. However, to do that we will need some additional policy and price support, likely.

The industrial sector is the third largest emitting sector. The sooner we actually use hydrogen in those sectors, the sooner we will see those emissions benefits.

Senator Capito. I mentioned permitting and how there have been some bureaucratic headwinds to getting these projects approved. How concerned are you about the permitting process

that we are seeing on the Class VI wells? And then there is the issue of permitting the transport of hydrogen as well. Could you speak a little bit about that?

Ms. Angielski. As it relates to the Class VI permits, you mentioned it in your opening remarks. I think there are almost 60 applications pending before EPA. One has a provisional permit out of the 60. Many of these applications were filed years ago.

You all obviously provided funding to EPA and the regional offices to really try to help expedite the processing of applications. The hope is that once EPA is able to staff up and get the expertise, I think there is also a lack of expertise at the moment to provide that resource and to serve the resource needs throughout the Country.

Hopefully, those funds will catalyze that and really help to accelerate processing of those applications. But it is a concern because obviously, as you know, the longer permitting takes, that is the time value of money for project developers.

The same is true when we are talking about any infrastructure component of a project, including pipelines, as you mentioned. I think probably the biggest concern is with respect to siting of pipelines and the time it takes to site. That is a permitting issue. It is also a local landowner and other regional or community set of issues.

I think appropriate engagement in the communities but then also a streamlined siting authority among the Federal agencies, in particular, would be really critical to go a long way in accelerating or processing those more quickly.

Senator Capito. Dr. Ellis, you mentioned that you are going to site your first manufacturing facility in Massachusetts. How far along are you on that project? Have you gotten into the permitting parts of that yet?

Ms. Ellis. Yes, we have already gotten into permitting. We were lucky to find a plot of land that was already zoned industrial.

Senator Capito. Was it a brownfield?

Ms. Ellis. It was a brownfield site. However, I would share your concern about permitting timelines. It is something where you can be a start-up to pool all these resources, but at a certain point, you have to hurry up and wait if you are being held back by permitting.

Especially with the enhanced scrutiny that comes with taking government funding from the IPA, for example, from the Office of Clean Energy Demonstration, if we were to win that funding, we would be subject to NEPA. That could very much create a situation in which we hurry up and then wait.

Senator Capito. So your permits now are just through Massachusetts, your State permitting?

Ms. Ellis. That is right.

Senator Capito. Generally they go faster. All right.

Thank you.

Senator Merkley is going to question, but Senator Whitehouse, I believe you are going to take the gavel from me. I will pass it along.

Senator Whitehouse. {Presiding} I will gladly do so.

Thank you so much.

Senator Merkley. Thank you very much, Mr. Chairman.

Dr. Regitsky, I unfortunately was at a foreign policy gathering, so I missed some of your presentation. As I understand it, Breakthrough Energy is a network Bill Gates helped set up, trying to find the innovative technologies that are necessary to bring to scale to meet the goal of net zero in 2050. Is that a fair summary?

Ms. Regitsky. Thank you, Senator. Yes, that is a very good summary.

Senator Merkley. In this process, building materials are obviously a key piece of this challenge. Could you comment a little bit about the role of mass timber as a substitute for buildings that are, say, 1 to 14 stories high and the comparison to traditional concrete and steel buildings?

Ms. Regitsky. Yes. Thank you for that question.

I will start by saying I am not a structural engineering

architect, a technical expert or anything like that. I have really focused on, how do you reduce emissions from heavy industrial producers.

That said, I think it is widely recognized that using alternative materials such as mass timber could be one of the solutions to be able to help decrease some of the current usage of things like concrete and steel in places, in buildings and structures where it makes sense.

But I believe it is also true that mass timber buildings still use some amount of those traditional materials as well. With the development that we expect globally, we still anticipate needing quite a bit of those traditional materials in order to really be able to develop these structures.

But yes, mass timber can certainly play a role in the buildings where it makes sense and where it can perform.

Senator Merkley. Where it can, and there may well be much taller buildings that are part of our world that require concrete and steel, both of which consume a lot of energy.

I was intrigued when I first came to the Senate by a company that presented me with a paperweight which was essentially cement made in a different strategy in order to capture carbon. Essentially, when this is put into a building, you have locked up carbon forever.

The downside was that the energy required to produce it and

the massive amount of water required to produce it meant that if you were looking at kind of the whole lifecycle of it, it wasn't a solution. There were very few places you could use that tremendous amount of water and of course the energy required to make it meant that you were producing carbon into the air to begin with.

But in terms of the investments that Breakthrough Energy is making, do you see a pathway where there are significant opportunities to greatly reduce the amount of energy that goes into concrete and steel buildings?

Ms. Regitsky. Yes. I think there are multiple companies within the Breakthrough Energy investment portfolio that are trying to solve this exact problem. For one example, there is a company called Brimstone. They are actually looking to be a drop in replacement for current cement production today, so no need to change the standards or the way that construction currently occurs.

But the process that they use can entirely eliminate the emissions from the cement manufacturing. It is an entirely different process than the way cement is manufactured today. They also create a byproduct that will capture carbon as well. So if everything, depending on the types of energy they end up using in their process, which they are compatible with clean electricity, they could come up with a potentially carbon

negative cement alternative that is a drop-in replacement.

There are many other companies as well that are finding new materials that substitute for cement as a binder so that you can use less cement in concrete since cement is the most carbon intensive part of concrete. There are many strategies out there today within the investment portfolio as well as other companies such as Sublime.

Senator Merkley. I think that is really important.

I am using that as a pivot to turn to you, Dr. Ellis, and your company. I love the name Sublime, given that you have a process to convert limestone to cement that consumes far less energy, and I think that is at the heart of it.

Have you, in your kind of analysis, really looked at kind of the whole cycle of the products so that you are including, kind of apples to apples comparisons with other products in terms of transportation, use of whatever source of energy is engaged and so forth?

Ms. Ellis. Yes, that is right. We have recently done an environmental product declaration with the industry's leading provider of these lifecycle analyses, both on the production of these materials.

I think what you say is very important, especially as it relates to mass timber. There is not only CO2 emissions in the production of these materials, but we also have to look at the

life cycle, the durability and the end use of these materials to make sure that carbon is avoided throughout the lifecycle and also that energy consumption is reduced in the production of these materials. For example, today, without Sublime's technology, the cement industry would have to decarbonize with post combustion carbon capture, which would double the cost and double the electricity consumption of cement making.

As it relates to cement versus timber, mass timber is a great material. As the other witness said, it can be used in many applications, especially in low-lying buildings.

But cement is unique in that it is very durable and strong. I think a material like this will be needed more than ever, especially in a changing climate where robustness and durability is important and the lifecycle that you can get from a building made with cement is unparalleled.

Senator Whitehouse. Senator Ricketts.

Senator Ricketts. Thank you very much.

I want to also thank Chairman Carper and Ranking Member Capito for putting this hearing together and our witnesses for sharing your perspectives with us here today.

We have talked a lot about carbon. One of the things I think often gets overlooked in these conversations when we talk about emissions and so forth, is that actually carbon is valuable beyond just kind of the obvious that you need carbon

dioxide in the air for plants to be able to grow. There are many uses for carbon that we need in our society. In fact, what many people don't realize is that actually in Nebraska, with our renewable fuels industry, specifically ethanol plants, we create some of the cleanest carbon in the industry.

It has many critical uses across our economy. For example, in our meat processing industry in Nebraska, carbon is used to rapidly chill meat, to be able to use it in transportation, to transport it, because we want to keep that food frozen as we are moving it around the Country.

We also use it in water treatment. Carbon is used to be able to take out, for the removal of organic chemicals during the treatment process. Of course in medical applications, carbon is used to sterilize medical supplies and development of pharmaceuticals and so forth.

Ms. Angielski, how can we continue to promote innovative uses of carbon which add value to our supply chain?

Ms. Angielski. I can speak at least to how carbon and hydrogen could be used together. If you look at the sustainable aviation fuels today, they need large amounts of carbon dioxide. If you capture that carbon dioxide, even better and they need hydrogen. So if you decarbonize the hydrogen, you can produce fuels that can really help to decarbonize industries like the aviation industry or some of these other maritime sort of

applications of what fossil fuels are using today. That is certainly one way to use it.

There are a number of CO2 conversion pathways. Obviously, putting it into processes like concrete is another way that has already been discussed, but I think the innovation needs to continue. Clearly, companies like Sublime and others that are trying to find innovative ways to decarbonize, but also funding provided by DOE to fund CO2 innovation and use is really critical to continuing to find markets for the product.

Senator Ricketts. You mentioned hydrogen. Let's talk about that for just a moment.

Nebraska has a long history of being an innovator when it comes to the agricultural industry. We have a company you may be familiar with, Monolith Materials, that has a patenting process, a unique process, to be able to take natural gas and crack it into hydrogen and carbon black. Carbon black goes into things like mascara, your tires, and cases for cell phones.

Typically, it is a very dirty process to make it from petroleum, but this is a clean process. Of course then we can have that carbon black to be able to make these products we just talked about that we need in everyday life. But also, you get hydrogen out of that. One of the uses for that is to be able to make clean anhydrous ammonia that then goes back into agriculture. We also have another company, Project Meadowlark,

that is doing the same thing with regard to taking hydrogen and so forth.

Can you talk a little bit about how hydrogen can make agriculture and other industries more efficient, cleaner, and promote economic development? What are some of the other things we can do as we have some of these opportunities to be able to use hydrogen in conjunction with carbon?

Ms. Angielski. Thank you for the question. You hit on a key industry or sector that, for a State like Nebraska, could really help contribute to decarbonization objectives for an industry and the agricultural sector that really doesn't have what I would say are very targeted solutions today that they have available to reduce their emissions from their processes.

Even in the agricultural sector, you mentioned at least Monolith and what they are looking at is to use decarbonized hydrogen as one of the feedstocks to produce ammonia and fertilizer. When you apply that, you could have agricultural products that are now decarbonized. You could also use hydrogen in many of the pieces of farm equipment that are needed to run and obviously farm the land.

Obviously, that is another area where that sector can really decarbonize from what they are currently using today, which is fossil fuels typically. Water irrigation systems need power. You can use hydrogen to power those. There is a lot of

opportunity, I think, for hydrogen to really help in the agricultural sector and decarbonize those emissions.

Senator Ricketts. Have you seen some of these applications for hydrogen being used in some of the hydrogen hub projects people are talking about?

Ms. Angielski. There are at least two hydrogen hubs that are looking at fertilizer uses and using the decarbonized hydrogen that would be produced in that hub as the feedstock to produce ammonia and fertilizer, so yes, definitely. I think ARCH2 is looking at that. If it is not ARCH, it might be the Midwest one, I believe.

Existing use cases for hydrogen are really what I consider to be the low hanging fruit for adopting decarbonized hydrogen in those sectors. It can really go a long way to helping create and stimulate the demand that clean hydrogen really needs to grow an industry in this Country.

Senator Ricketts. Great. Thank you very much.

Ms. Angielski. Thank you.

Senator Whitehouse. The gavel reverts to you.

Senator Carper. [Presiding.] Thank you so much.

Senator Ricketts. Chairman Carper, as I promised, I did get a chance to mention our ethanol industry in Nebraska in this hearing.

[Laughter.]

Senator Carper. I knew we could count on you.

Thanks so much. It is a good morning, a full morning. This hearing is off to a good start. I have asked people on both sides of the aisle and they are very complimentary of the witnesses and the tone you are helping us to set. I have a couple questions and will jump right in. I appreciate Senator Whitehouse filling in for me.

Dr. Regitsky, in the Fifth National Climate Assessment that was released yesterday, I mentioned it earlier in my opening statement, some 14 Federal agencies and hundreds of our Nation's top scientists explained the urgency of cutting greenhouse gas emissions. We know that Federal actions are key to unlocking swift and sharp emission reductions from industry. That is why the EPW Committee provided funding through the Bipartisan Infrastructure Law and the Inflation Reduction Act to support near-term actions and transformative technologies to reduce emissions from heavy industry.

With that as a backdrop, let me ask this question of Dr. Regitsky. Would you please describe ways in which the programs enacted under the Bipartisan Infrastructure Law and the Inflation Reduction Act are supporting our efforts to decarbonize heavy industry?

Ms. Regitsky. Thank you, Senator, for the question.

What you relayed in your opening statement and has been

discussed by other witnesses as well, there are many programs within the Infrastructure Law and Inflation Reduction Act that are going to help industry progress on its way to industrial decarbonization. Just to name a few that I think are really important and to just highlight a key piece that the two bills do together is really match supply support with demand support, which is really important.

So on the supply side, as I mentioned in my testimony, over \$6 billion at the Department of Energy to support industrial decarbonization demonstration projects. This is historical. There has not been this amount of funding to industrial decarbonization ever from the U.S. Government.

The fact that it is for commercial scale demonstrations, first of a kind facilities, is really critical because that is really going to be able to support the transformative technologies that we really need to get to net zero, as well as the incremental emissions reductions that we need as well.

This is a program that I am personally very excited about. We are waiting now for DOE to make the selections, which I believe will come out early next year.

I already mentioned, too, that the industry appetite for this program has been immense. There were ten times the amount of requests for funding than the \$6.3 billion, which just shows how much it means.

Senator Carper. Did that surprise you?

Ms. Regitsky. Maybe I was a little surprised, though maybe I should not have been, because the investments that will be required to truly decarbonize all of heavy industry is going to be massive. Six billion dollars sounds like a lot, but it is really just a fraction.

I think that the ten times initial need for this first program to come out just gives us a glimpse of what industry is really looking for. Then just to say, there are many other pieces that witnesses and members have already mentioned. The hydrogen hubs, of course, will be critical to using clean hydrogen to decarbonize industry.

Also very many tax incentives in the Inflation Reduction Act that will be relevant for industry; 48C, an investment tax credit for reducing industrial emissions in existing facilities; 45D for clean hydrogen, 45X could be really game changing for thermal storage, which I mentioned in my testimony, to really unlock the ability of those thermal batteries to decarbonize industrial heat, and many more.

On the demand side, it is really great that these investments were paired with the almost \$5 billion to Federal agencies for procuring low carbon materials. So the government is helping companies invest to make their materials cleaner and then creating the markets for those clean materials to really

match that supply and demand and show the industry that there is a buyer for the clean goods that they are going to be making.

Senator Carper. Thanks very much for that.

I have a follow-up question, then I am going to turn to Senator Padilla for his questions.

You have already responded to this question in part, but I am going to ask it again more directly to see if there is anything you want to add. What role does public investment play in the technology development life cycle? How can we, as policymakers, ensure that technology developers can continue to overcome the barriers to deployment?

Ms. Regitsky. I am happy to elaborate on that follow-up question. The government support all across the innovation cycle is going to be critical, definitely in the early stages where really this isn't where private capital comes in at all, where folks are still discovering their technologies in the lab, and really kind of fine tuning these technologies.

The government really has a place to step in throughout the development. So taking that lab technology to a pilot scale, to then a larger scale demonstration, to then financing for even further deployment. A big part of technology development is risk. So where the government can come in is to really help de-risk these technologies and accelerate their ability to go through development and get to scale.

One quick thing to mention is just, innovation is messy. It is a feedback loop. You make progress, you fail, you learn, and then you eventually succeed. You can't really skip any of those steps. So what the government support helps to do is de-risk at every one of those steps, make sure that learnings are able to be shared between entrepreneurs. It just accelerates the process.

Senator Carper. Thanks for that response.

Senator Padilla, it is good to see you this morning. Welcome.

Senator Padilla. Thank you, Mr. Chairman. Kudos to you for having multiple witnesses today with affiliation with the Massachusetts Institute of Technology, a brilliant move. You can tell when there is 120 pages of testimony submitted, MIT folks who are involved.

[Laughter.]

Senator Padilla. California prides itself in having one of the lowest emitting cement factories in the Country located in Redding, California. We also helped to forge startups in a network of ten companies referred to as DC2 that are committed to going even further by making cement and concrete with no, or very low, emissions. However, as I have discussed at previous hearings, most current tax credits reward companies that first emit and then capture their emissions, but not as much for

companies that are lowering or eliminating their emissions altogether.

My first question is for Dr. Ellis. As a member of the DC2 Alliance, can you speak to your company's experience with the current tax incentives like Sections 45Q, which I think has been raised already, and 48C, and the agencies that developed and oversee them?

Ms. Ellis. Thank you so much. This is a really important question.

Right now there is no tax credit available for technologies that avoid the manufacture of carbon. Sublime Systems submitted a concept paper for 48C and we were discouraged from the full application.

And 45Q creates perverse incentives. Sublime Systems could manufacture carbon and monetize it by using limestone as an input material from our cement. But we believe that is wrong to do. That is not very forward looking and it is the wrong use of this tax credit.

Instead, the Congress and the Treasury should consider technology agnostic tax incentives to reward the avoidance of carbon as much as it does for carbon production, capture and storage.

Senator Padilla. An ounce of prevention is worth a pound of cure. That is my translation.

The second question is for Dr. Regitsky. You were involved in the Sierra Club study of cement factories in California and other States. What lessons did you learn regarding innovations in decarbonizing cement and concrete at factory scale?

Ms. Regitsky. Thank you for the question, Senator.

This was a really groundbreaking study that was conducted because of the facility level data that it provides. Of course, these are just estimates. These are actually very difficult numbers to get, to have production data from facilities.

But what these estimates are providing us is to really have a granular view of the performance of different facilities, so we can get an idea of what the average performance is, how well the top performing facilities are doing, and how well the bottom performing facilities are doing. These are all existing facilities.

So by looking at that difference, you can see what is already possible, even just using the best available technology today and where those kind of near-term emission reductions are possible. The study has really been able to showcase this in cement as well as a handful of other sectors. It really showcases the usefulness of this type of data.

To bring this back to a conversation we had earlier in the hearing, I mentioned this is difficult data to come by. The U.S. Government actually has all of the data to come up with

these numbers in existing reporting. The Census has these production numbers from these facilities, but of course, it is kept very confidential for good reasons. But the PROVE IT Act discussed earlier would actually start enabling the sharing of this type of data between government agencies so that the government can start seeing what these emissions are, get the averages, and all of that as well.

Senator Padilla. Thank you. One more question, Mr. Chair. This builds on an item that Senator Whitehouse raised earlier in the hearing.

Looking ahead to COP28 this month, it is important to consider the global scale needed for industrial decarbonization as countries around the world increase their demand for concrete and other building materials.

Dr. Ellis, Sublime has a goal of producing a million tons of concrete by 2028. That is very laudable, but in the United States alone, our demand exceeds 100 million tons. How can we help scale up low- and no-carbon emission concrete companies to the level needed to effectively supply the national and global market?

Ms. Ellis. Thank you, Senator.

The Office of Clean Energy Demonstration, combined with the Low Programs Office, is an excellent first start. If we are successful in applying these two programs, it will support us

through a phase of growth where we can achieve economies of scale and reduce costs so we can compete on cost with today's carbon intensive Portland cement. These programs need robust support beyond these initial appropriations.

Also, as Senator Markey said earlier, if we move quickly to create government advance market commitments, since the government buys 60 percent of the concrete used in the United States, if we move quickly with these advance market commitments to bring these clean technologies to scale, we can move to export these technologies to the rest of the world where new greenfield cement plants will be built in a period of dirty growth in India, Africa and places where the world's population is growing and becoming more urban. We have an opportunity to act now to prevent decades more CO2 emissions from these carbon intensive industries.

Senator Padilla. Thank you so much. I appreciate your leadership.

Thank you, Mr. Chair.

Senator Carper. Thank you, Senator Padilla.

We have been joined by Senator Fetterman, my neighbor across the line in Pennsylvania.

Senator Fetterman. Thank you, Mr. Chairman.

Senator Carper. You are welcome. You are recognized.

Senator Fetterman. Thank you, everybody.

I am sure you probably don't know this, and it is probably not very interesting as a fact, but I live right across the street from a steel mill. Literally, it is the last functional steel mill in all of western Pennsylvania, which is a remarkable statement because that is where more than half the world's steel was actually manufactured back in the middle of the 20th century.

I have been in conversations with the leadership of U.S. Steel over the years. One of the things now that just came onto their screen about now is, we have a mandate to do decarbonize our industry. I was like, wow, that is remarkable.

How can you possibly decarbonize steel? If anyone has seen a video of it or is familiar with it, it is a very violent and explosive kind of a process. It is very, very dirty. I know that very well because you have to scrape it off the windows and things at our home.

I asked the leadership, and said, to me decarbonizing the steel industry would be like having a steak house that you don't have a dead cow. It seems kind of incompatible. How is that possible? Then they started saying, well, you know, hydrogen with that as well.

Then I asked, where do we get the hydrogen from? Because my understanding is that it comes from natural gas. Is that accurate, to any experts? Is that accurate?

Ms. Angielski. I am happy to answer that question, Senator Fetterman. Today, the majority of hydrogen that is produced comes from reforming natural gas. You are correct. You can lower the carbon emissions of that process by capturing and storing the CO₂. So you can still use natural gas, decarbonize it and reform it so that way it can be used in the steelmaking process. That is certainly one way to decarbonize the steel industry.

Senator Fetterman. Of course, obviously, you are experts and again, much smarter than I am, but I know natural gas is a fossil fuel. It does have carbon involved. Of course fracking is often very controversial, certainly within the Democratic Party and in Pennsylvania as well.

My next question is, if it is coming from natural gas and is turned into hydrogen or where it is made the way, it is currently under the most stringent kind of environmental requirements, is that really what is happening? Are we decarbonizing steel or are we green washing that? What does that mean to the average union worker who might be thinking, I am going to lose my job because we are not able to meet some of these standards.

Politically, those are the ones that are going to run to the Republican side and the steel is going to go to the industries all across the world that make steel without any

labor unions, without any kind of environmental kind of restraints, or all these other kinds of things.

I would very much like to decarbonize steel, but these are the kinds of industries that have I think a very truth that you can't really make it without having carbon involved unless there is some kind of super, next kind of a paradigm shift.

How is that possible? What can be really meaningful having that conversation in industries like that which are a part of the western Pennsylvania legacy? Is there a path forward on that? I would open that to anybody.

Ms. Angielski. I would be happy to start, Senator. I want to touch on your jobs component of this because I think the unions and job market writ large, whether we are looking at just the fossil fuel industry or a clean energy industry, I think existing jobs are going to be the underpinning for the transition. If we are going to transition to these clean jobs, we will continue to need that union labor.

Again, I would say Congress and what they did in enacting the IIJA and of course the IRA, all of these requirements to make sure that we have apprenticeship programs to train and skill workers in these new industries will be critical for that.

But we will need that labor, as it relates to natural gas and the use of natural gas to produce hydrogen and or to replace the fossil fuels that are used in the steelmaking process. As

we drive towards zero emissions, a hydrogen profile or an emissions profile, I should say, I think we are going to need the natural gas industry with carbon capture and storage to really help build out the infrastructure that is going to be needed to get to that net zero emitting carbon intensity hydrogen production method, so that way it can be used in decarbonizing these industries, whether it is steel or other industries.

Senator Fetterman. Mr. Chairman, 30 seconds?

Senator Carper. At least 35.

Senator Fetterman. Thank you.

I guess the final question on this is that perhaps you are aware of how controversial natural gas and fracking is now. Despite all that and the realities that are a part of that, and I do support natural gas, are we being honest about decarbonizing an industry like that? Is it meaningful? Is it genuinely meaningful and all that? Is that dangerous because if we just say we are not going to even make these in America anymore, now we are running right into the arms of a foreign kind of steel manufacturers?

Ms. Regitsky. If I may I take on this question, Senator, I think that is a very fair question.

There are other ways of making steel, even primary steel, that is being developed now that would altogether remove fossil

fuels from the process and still deliver that primary, high quality steel we need in several industries today, and that actually have the potential to grow the U.S. domestic steel market share.

BCG came out with a study that the global clean steel demand in 2050 is something like \$1 trillion. The U.S. has the ability, if we make investments now in a variety of technologies, to be able to capitalize on that. So, things that use clean electricity, and bypass fossil fuels altogether.

And just a comment on the natural gas pathway. While natural gas and using carbon capture to create hydrogen is certainly one way to create a form of low emissions hydrogen that could go into steel making, the process that that would use is a direct reduction process that actually in Toledo, Cleveland Cliffs had the direct reduction iron process with natural gas already.

The way that you would introduce hydrogen into the steel making process is through the same type of process. If you are thinking about efficiency and energy efficiency, where the more efficient you can be, the fewer your costs, the more product you are making, the more revenue a company is generating. If you actually start with natural gas, then make hydrogen, and then put it into a DRI facility, you are adding an extra step rather than just going straight from hydrogen in the facility itself

without that step.

I think that is where the importance of things like the hydrogen hubs trying to stimulate the supply of clean hydrogen from a variety of sources beyond just the natural gas dry hydrogen, but clean hydrogen from electricity as well, can really be what unlocks that ability for clean hydrogen to be used in the steel industry to provide truly clean primary steel.

Senator Fetterman. I genuinely apologize. I am sorry this has gone so far. Thank you for the opportunity. Thank you, everyone, for answering all my questions.

Ms. Ellis. Mr. Chairman, may I weigh in as well on Senator Fetterman's prompt?

Senator Carper. Okay.

Ms. Ellis. I want to commend you, Senator Fetterman, on your point about using natural gas as a stopgap solution for decarbonizing steel. This is something that we think of as well. Sublime Systems has a true zero, not a net zero, way of making cement. We don't emit CO2 in the first place. I think that is very important.

The witness from Breakthrough Energy mentioned that there are innovative technologies that are avoiding CO2 emissions in the first place, both for cement and steel. I also want to add that we have signed an agreement with the United Steelworkers Union for labor for our first commercial plant to make this true

zero cement. The United Steelworkers Union employs 50 percent of the cement workers in the United States. We believe it is very important for these workers to bring their skills.

We bring this new innovation and this electrochemical manufacturing. They bring the knowledge, skill, expertise and the safety skills to build this new plant. I do think that together with our innovation and with the workers from the old manufacturing, we can bring American manufacturing into a clean energy future.

Senator Fetterman. I sure hope that is true, because the union workers that I live next to and talk to see that as, well, it might be the end of our career in making steel in the Mon Valley.

I have gone way, way, way too long. I apologize. Thank you.

Senator Carper. Thanks so much for being here. Thanks very much for your questions and for sparking a pretty darned good discussion.

We may have another colleague or two to join us. More than half of the committees are meeting right now. So people are trying to be in several places at once.

I have a question I want to ask Dr. Regitsky. We do not mean to be picking on you, ma'am. You are good to join us even remotely.

I would like to talk a little bit with you about near-term technology solutions. Many of the transformative technologies that will enable deep decarbonization, such as entirely new ways to produce clean materials, will require time to reach commercial scale. I think we realize that.

As the just-released Fifth National Climate Assessment makes all too clear, we don't have time to wait for these solutions to come to market as the climate crisis progresses. While those new technologies develop, many tools are already available to make meaningful emissions reductions today. That is good news.

Dr. Regitsky, in your written testimony, you discussed various methods that can be deployed in facilities today to achieve meaningful emissions reductions. Would you just take a few minutes and share with us some specific examples of existing methods that can deliver immediate results?

Ms. Regitsky. Thank you for the question, Senator.

There are definitely a host of available technologies today that can be used to start reducing emissions now. I would say at the top of the list is energy efficiency. In any sector, that is always your go-to solution. Any time you are able to become more energy efficient, you are saving costs. So really, it is a win-win.

With new technologies like smart manufacturing, where you

can go in and add smart sensors to your different equipment, really monitor the performance of equipment, and really optimize that energy usage is really increasing the opportunity for energy efficiency even more.

On electrification, especially of low temperature heating process, for example, the food and beverage industry is one big user of low temperature heat. Rather than using natural gas to create that heat, electric heat pumps are a viable option today to be able to generate that low temperature heat and reduce a significant portion of those types of emissions across industrial sectors. Of course, electrification will also require infrastructure for that clean electricity and continued cooling of the grid as well.

As a final example in the cement and concrete space, it is really great to see the innovative technologies, the transformative technologies like Sublime is developing. But in the near-term, there are things called supplementary cementitious materials, SCMs, that can be used to reduce the cement content within concrete, so you are reducing the emissions of your concrete mix.

Right now, a lot of these are sourced from current industrial wastes, fly ash from coal, slag from steel production, but we know that these things are not going to always be in supply as those industrial processes start

decreasing.

So there are companies who are actually creating synthetic SCMs from widely abundant sources near already existing concrete infrastructure that can start supplying more of these materials to reduce that amount of cement per unit of concrete. That is something that can be done today.

Senator Carper. Good. Thanks a lot.

My next question I would like to direct to Dr. Ellis. This question deals with keys to adopting clean cement.

We rely on a variety of materials that must meet our rigorous standards in order to ensure safety and longevity. The steel that reinforces our buildings and the concrete that supports the transport of people and goods functions under a variety of scenarios.

National standards organizations play a role in setting performance standards for all kinds of materials, but local entities are often responsible for enforcing those standards, as in the case with building codes.

Dr. Ellis, my question is, how does the performance of cement made from new processes compare to the traditional cement production?

Ms. Ellis. That is a fantastic question. Thank you.

For many years, cement was defined by its chemistry and not just the stoichiometry, the items and the elements present, but

the crystal structure of the cement. Today's Portland cement is made in a large kiln and that crystal structure can only be made in a kiln.

So if we want to decarbonize cement, if we want to employ the supplementary cementitious materials, they can be swiftly and massively deployed as the witness from Breakthrough Energy just mentioned, it means we have to change the definition of cement to be from a prescriptive-based standard, which specifies the crystal structure of the cement, to a performance-based standard.

The good news is that this change from a prescriptive to a performance-based standard happened decades ago. In 1992, ASTM International, the standards-making body, created this performance-based standard. This is a standard that Sublime cement applies to and we meet and, if not, exceed this performance-based standard. This means that our cement reacts with water, gel sets and hardens to make the same durable concrete that we have been using for decades and millennia. It is very important that the infrastructure that we are building, especially with public funds, is durable and safe.

Senator Carper. Thanks.

I think you partly answered this question, but I am going to ask it anyway and see if you would like to add any other thoughts. This is for Dr. Regitsky.

Would you comment on the need to update specifications and standards to help improve the marketability of clean products? Also, what are some other examples of clean materials other than cement that will require such updates? Dr. Regitsky?

Ms. Regitsky. Thanks for the question, Senator.

I can certainly build off of Dr. Ellis' response previously that these performance-based standards exist today. The standard-making bodies have created them and there are products that meet these standards.

But the issue is that the standards and specifications need to be adopted by the people in charge of creating whatever the project is, infrastructure or buildings. For example, State DOTs are one player that is really important in a regional market. If a State DOT adopts a specific specification, then most suppliers in that market will want to meet that specification in order to be able to access the State DOT infrastructure projects.

We saw that this change happened with a type of blended cement called Portland Limestone Cement, PLC. It blends about 10 percent limestone into a cement mix, so can reduce emissions largely that way. Now that is already accepted in a majority of State DOTs today and has really impacted the adoption of this new cement blend.

We are able to do that same kind of State DOT adoption to

just performance-based standards, as Dr. Ellis mentioned. That will be a game changer for innovative technologies that don't necessarily meet the strict definition of what cement is today, but can meet the performance requirements of these structures.

Being able to partner with organizations like State DOTs, with private sector and public sector building projects in order to make people comfortable with these types of performance specifications is going to be really critical.

Senator Carper. Thanks for that response.

I want to talk a bit about hydrogen and industrial decarbonization. Ms. Angielski, how is the existing industrial infrastructure adapting to incorporate hydrogen technologies? Again, how is the existing industrial infrastructure adapting to incorporate hydrogen technologies?

I understand that the industrial processes that are used in the production of things like steel, cement, glass, and chemicals all require high temperature heat. Currently, this heat is produced by burning fossil fuels. For these processes, hydrogen can play an important role in helping us reach net zero goals.

How easily can hydrogen be integrated into existing industrial processes without major modifications and how is the existing industrial infrastructure adapting to incorporate hydrogen technologies?

Ms. Angielski. Thank you for the question, Chairman.

I would say that at least in the industrial or the existing industries that use hydrogen, they are looking at ways to produce low carbon hydrogen at a cost that would be equivalent to how they produce or use at the same cost of what is called gray hydrogen produced from natural gas today. The industries that you mentioned that are potential users of hydrogen are waiting for hydrogen production costs to come down in price in order for them to begin to adopt using hydrogen in those processes.

The important thing to understand is that the cost of hydrogen today is, on average, roughly about \$1 per kilogram and that is how it is measured. That equates to about \$7.50 per MMBTu of natural gas on an energy content basis.

So if you are looking at a price point of a dollar as a replacement for natural gas as the incumbent fuel in many of these processes, the price of hydrogen will also need to go down in order for that natural gas to be substituted using hydrogen.

Some industries, some steel-making industries here in the U.S. are looking at becoming like hydrogen ready, is what they call it, to make sure that they have the ability to adopt hydrogen when the price comes down or there are sufficient volumes to be able to use hydrogen.

Other industries are looking at utilizing, as I mentioned,

existing infrastructure, so there are some producers on the Gulf Coast where there is a pretty thriving hydrogen industry already. They are looking to produce hydrogen and try to do so in a way that would be able to be cost effective for their already existing industrial customers to be able to adopt the hydrogen in those industries.

So everybody is moving towards or moving in a good direction. Let's put it that way. We are waiting for the tax credit policies and the guidance coming from Treasury that will be really helpful in stimulating that activity and behavior.

Senator Carper. In terms of bringing down the cost of hydrogen, what have we done in terms of policy, tax policy, the legislation that we enacted, what have we done that is actually going to help with respect to bringing down the cost of hydrogen? What more could the government do or academia do, or are there other ways that could help bring down the price of hydrogen?

Ms. Angielski. Absolutely. I know Abigail and others, as witnesses, can speak to this as well. I am happy to do that. Senator, you led on the Section 45E tax credits, these production tax credits. They are going to go a long way in stimulating production of clean hydrogen.

I think if there are policies that can be implemented to help offset that cost differential that I was just describing in

terms of the replacement cost of using hydrogen in those sectors, that would go a long way towards stimulating the demand in those industries and help really drive adoption of decarbonized hydrogen in those processes.

Senator Carper. Do any other witnesses want to comment on that with respect to bringing down the cost of hydrogen?

Ms. Regitsky. I am happy to add to that question, Senator. I certainly think the policies that the government has already put in place which Congress passed in the Infrastructure Law and Inflation Reduction Act, as Ms. Angielski already mentioned, will certainly help on that supply side in bringing the costs down.

The Department of Energy certainly has this in its sights with its Hydrogen Earthshot and really bringing down the price of clean hydrogen to that \$1 a kilogram figure. So these policies are already in place.

A big important thing is getting them implemented. So on the 45B tax credit, just to make sure that guidance is out quickly. The lack of the guidance is really kind of stalling investor investing into new clean hydrogen projects and electrolyzers. That is definitely going to be a key piece of ensuring that the policy is meant to do what it is supposed to do and is able to bring those costs down.

Senator Carper. Thank you.

I am going to ask a couple of open-ended questions here and ask you to think about them. I like baseball. There is a saying in baseball about the pitcher telegraphing his or her pitch. It means the batter, whoever is watching the pitcher or the way the pitcher holds the ball, releases the ball and throws it to the plate, the pitcher gives away what kind of pitch it is going to be, fastball, curveball, or whatever.

We are going to turn to Senator Sullivan when he gets settled.

The last question I will be asking you is to think about out loud is where you agree. I think sometimes we have witnesses that don't agree on almost anything. I try to look for a couple of things where we can agree. I think there is a fair amount of agreement here amongst the three of you. So before we wrap it up, we will come back and ask, where do you agree?

With that, Senator Sullivan. It is good to see you.

Senator Sullivan. Thank you, Mr. Chairman. Thanks for waiting. Thank you to our witnesses. Appreciate you guys being here.

I show this chart a lot. It is actually really relevant for today because President Biden is meeting with President Xi Jinping. There is a lot of talk about emissions globally since 2005 to 2020. This has been fact checked and everything.

The emissions of China, we all know, are kind of through the roof. Nobody disputes that. Our emissions have actually declined pretty dramatically. The reason is we had a dramatic revolution in the production of natural gas. I think very few people argue with the reason why that went down.

So my question for you, my question for the witnesses is, to what extent do you think mandating, and very little of that was mandated, it was the private sector that innovated on the issue of hydraulic fracking and then kind of the extended reach drilling, which we do in Alaska, which shrinks the surface footprint and makes it much more environmentally sustainable.

To what degree do you think, in the industrial sector, the Federal Government should be mandating issues? There is an article I would like to submit for the record, from the New York Times. Mr. Chairman, I don't normally submit articles from The New York Times. The title is Biden to Target Industrial Pollution in Second Term, If He Gets One.

Senator Carper. Without objection.

[The referenced information follows:]

Senator Sullivan. A lot of this article focuses on mandates to industry, you have to do this and you have to do that, to industry. One of the challenges of that, of course, is that sometimes you miss innovation. Again, nobody argues that we are actually the leader in the reduction of greenhouse gas emissions. China is the dirty polluter. I hope the President brings that up in his meetings with Xi Jinping today.

That wouldn't have happened, in my view, which benefits everybody, let alone jobs and the environment, had there been a heavy-handed approach from the Federal Government saying, here is exactly how you need to do this. That revolution in the production of natural gas, nobody believed that could happen. The story is quite remarkable, but it really is essentially a lesson in the innovative capacity of the American private sector.

So I am curious, for both the witnesses, this is kind of an open-ended question for all the witnesses. When you go for certain goals, if the feds come in and say X, Y, and Z has to happen, a lot of times you miss the opportunity for the innovation that can make things even better. Do either of you have an opinion on that?

Ms. Ellis. I do, Senator Sullivan. I would like to thank you for sharing that graph. That graph actually made me very proud to be American and to see the leadership that we have

taken in adopting new technologies quickly and having an impact.

I believe that what I am doing at Sublime Systems, developing a new technology to make cement that is true zero, not net zero, which means that we won't have to add additional cost, additional energy, additional labor into decarbonizing cement production, I think that is very important for us.

Senator Sullivan. Sorry to interrupt, but it is a great point. Are you doing that because the feds or the Congress said to do this or are you just saying, hey, this can be great for my company, great for my community, great for my State, great for the Country, and help the environment?

Yes, we are a capitalist society. Make some money. There is nothing wrong with that. Why are you doing it?

Ms. Ellis. I am doing it because I think it is important. I think it is important to move quickly. I see it as a tremendous opportunity to develop new technology, and I think history has shown that the U.S. Government has had a role in catalyzing the development of new technology, be it through NASA or the internet.

I know there are countless other monumental technologies that have just had that that partnership with the government to bring new ideas that are made in America and to export them globally. The U.S. produces 100 million tons of cement per year, but we also import about 20 percent of our cement from

overseas.

Senator Sullivan. From where?

Ms. Ellis. From Turkey, Greece, Vietnam, Canada, really from all over. I think this is a great opportunity to export made in America technology to India, Africa, China, to these places that have these incredibly polluting heavy industrial assets, because we know that climate change affects all of us, in the U.S. and elsewhere.

Senator Sullivan. That is one reason I am a big fan of exporting American, clean, burning American LNG. It is the same analogy. Thank you for that.

I know we have a witness virtually. Mr. Chairman, I would like to hear from that witness.

Ms. Angielski. Thank you, Senator. Thank you for the question.

I would say that many of our members right now are already committed to innovative approaches to decarbonizing their operations. Many of them are industrial sector producers and users of their products.

Senator Sullivan. Do you worry about that article I just cited?

Ms. Angielski. I haven't had a chance to look at it. What I can say is that absent mandates at the moment, these companies are committing and investing. They are looking at other policy

tools and levers, of course. We were very much advocates of the clean hydrogen hubs and for the Section 45B tax credits.

Part of my testimony has also called for action on helping to reduce the costs for adopting hydrogen as a replacement fuel in many of these industrial sectors. That is not a call for a mandate, but there will be a need for policy tools and levers to continue to both produce and use decarbonized hydrogen.

Senator Sullivan. So more flexibility with tools versus strict mandates. In Alaska, we always say, particularly with regard to the feds, the one-size-fits-all approach just did not work for our State. When D.C. is making rules, oh, we are going to apply that to all of America, inevitably that does not work in my State. So, flexibility and tools, but maybe not so strict mandates? Is that kind of what you are saying?

Ms. Angielski. We haven't taken a position as a coalition on mandates because there hasn't been a discussion about industrial decarbonization and mandates for it. I hold the fact that our members are already investing and looking towards a future that is decarbonizing and making those investments today. Then partnering with the Department of Energy in innovative approaches to do that is going to be critical to making sure that we are successful.

Senator Sullivan. Great. To the online witness, do you want to take a crack at that if you are still online?

Ms. Regitsky. Yes, Senator. Thanks for the opportunity.

Certainly mandates are one type of policy that can reduce emissions, but certainly not the only one. What is important, which I think has already been discussed by the other witnesses, is that what we care about is emissions and in industry, a lot of time emissions intensity. How many emissions are being produced every time you make a ton of cement or a ton of steel?

That is really the factor that we care about. Policies that are smart, that can target that kind of data point, emissions intensity, but then allow industry to innovate and use whatever tools are necessary to meet that target is really what is going to help innovation the most.

It will help create this level playing field so that innovators who are aiming for the most emissions intensity savings stand to benefit the most because those are the technologies that we are going to really need to transform the heavy industry. Thinking about smart policies that incentivize innovation is certainly helpful.

Senator Sullivan. Great. Those are great answers.

Mr. Chairman, thank you. I do think to the witnesses' point, it is a great strategic advantage of America, particularly relative to China. We can be doing that in a much less carbon intensive way here and then exporting and beating them at their own game.

Thank you, Mr. Chairman.

Senator Carper. Thanks so much for joining us and for your questions. It will be interesting to hear what comes out of the meeting today between President Biden and President Xi. We are all ears.

We are about to wrap it up. Areas of agreement, a lot of times folks in Washington, even in the Senate, focus on disagreement. In this committee, we actually focus a lot more on, where do we agree, or how can we find common ground and build on that.

Let me start, if I could, with Dr. Ellis. What are some major areas of agreement that you think you would like to just emphasize for us in closing?

Ms. Ellis. Thank you. I think we can all agree that our solutions are urgently needed and that they are very important. This is also a massive opportunity for us to work together and to really surmount this challenge and to create more jobs in America, to reduce imports, to increase exports, and bring high quality jobs back to old manufacturing towns with new technology that is also clean and benefits the community more.

Senator Carper. Thank you.

Ms. Angielski?

Ms. Angielski. Thank you, Senator. I think what I would like to say is that the time is now, especially as we think

about clean hydrogen. This industry needs to grow and it needs to grow very rapidly if it is going to be able to play the role that it needs to play as a decarbonization solution.

This is a very large, complex ecosystem. The industrial sector is a very large, complex ecosystem. Clean hydrogen is only one aspect of that, but it touches many industries and many sectors.

For the solution to be able to be used and achieve decarbonization objectives, I think much of the policy that we have in place, thanks to you and others in Congress, that will be a great starting point. We need to continue to work together in looking at policy for making sure that ecosystem can grow and enable clean hydrogen to serve the role that it is supposed to.

Senator Carper. Good. Thank you.

Batting cleanup, Ms. Regitsky.

Ms. Regitsky. Thank you, Senator. I would certainly agree with what Dr. Ellis and Ms. Angielski have already mentioned on the opportunity that industrial decarbonization brings for American workers, for the American economy, for really the competitiveness of American industry internationally, as well as all the community and health benefits as well that will come along.

The time certainly is now, we have policies in place, thanks to Congress, that are really getting the ball rolling but

we will need much more. This is really going to be a collaboration between the private sector and the public sector. Innovation is really at the center of it all and really being able to propel that innovation for these technologies to get us to a net zero industry.

Senator Carper. Good. Thank you.

In closing, I want to thank each of you, all three of you, two in person and one remotely. Thank you for joining us today. Thank you even more for sharing your insights and your perspectives on what I think we all realize is a hugely important topic for not just the Congress, but for our Country and for our planet.

To put it simply, we are all experiencing climate change now through and increasingly devastating extreme weather events throughout our planet. To slow climate change, we need to slash greenhouse gas emissions and one third of the solution lies in our industrial sector, one third.

Today, we have heard some good news. We do not always share good news here, but today there is some good news. By investing in clean, low, and zero carbon manufacturing, we are growing back good paying jobs, American competitiveness and our economy, as well as cleaning up local air pollution and fighting the climate crisis. Today's hearing gives us a game plan for what we must do going forward.

Before we adjourn, we have a little bit of housekeeping. Senators who were here or not here are welcome to submit additional questions for the record until the close of business on Wednesday, December 6th. We will compile those questions, we will send them over to each of our witnesses and we will be asking the three of you to reply to us by Wednesday afternoon, December 6th. No, not really. You will have you have until Wednesday, December 20th, two full weeks for some really good answers. You have given us some really good answers already and we applaud each you very much.

Thanksgiving is coming up. It is one of my favorite holidays. I think it is one of our favorite holidays in America.

I hear a lot of people say, it has never been this bad, it has never been this bad on our planet, in our Country, or whatever. I always remind them that things have been a lot worse. We had a civil war. We lost a million men. We followed that up with two world wars, the Great Depression, when one out of every four people didn't have a job that wanted a job. We took on communism. We have been through worse than this.

To the extent that we can pull together, share ideas, find ways to harness technology, and really create economic opportunity out of the technology that we are talking about here with clean hydrogen, there is a lot to be happy about and to

look forward to.

So we will compile the questions and send them to you and look forward to your responses to them by December the 20th.

With that, a very happy Thanksgiving coming up and I look forward to seeing you on the other side. Thanks much.

With that, this hearing is adjourned.

[Whereupon, at 12:07 p.m., the hearing was adjourned.]