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AN EXAMINATION OF EMERGING OFFSHORE AND MARINE ENERGY TECHNOLOGIES IN THE UNITED STATES, INCLUDING OFFSHORE WIND, MARINE AND HYDROKINETIC ENERGY, AND ALTERNATIVE FUELS FOR MARITIME SHIPPING

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED SIXTEENTH CONGRESS

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TUESDAY, SEPTEMBER 22, 2020

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:16 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning, everyone. The Committee will come to order.

We are meeting this morning to examine the development of emerging offshore energy technologies, including renewable resources like offshore wind and marine energy. First of all, I need to start the discussion this morning by just saying how much I love this topic. I hope my Ranking Member is paying attention. I just get so excited about this discussion, because I think the opportunities here have so much potential.

I do want to make one clarification. I think that when most people hear the phrase "offshore energy," they automatically think of offshore oil and gas development, and while we absolutely, absolutely, recognize that those resources are an important part of our energy mix and contribute greatly to our energy security, oil and gas reflect only part of the potential that we have to use the ocean as a source of energy. There are numerous other ways to produce and consume energy in the ocean. Those other offshore technologies have always been on the fringes here in the United States, but because of a number of technology and policy developments, we are finally starting to see them take shape and it is exciting.

First, of course, is offshore wind, which is poised for significant growth in the years ahead. The two small installations off the coast of Virginia and Rhode Island have served as useful test beds and analysts are now expecting more than 20 gigawatts of potential growth this decade. I had an opportunity to go out to Block Island and see for myself what they are doing out there some years ago.

I have been following the development of a comprehensive environmental impact statement for the Atlantic Coast. I look forward to learning more about that process today.

I also want to note that Alaska has more offshore wind energy potential than all the other states combined. I am always talking about how big Alaska is and how extraordinary its energy potential is, but we have some 33,000 miles of coastline in Alaska. We have some pretty extraordinary rivers and we are surrounded by three seas and an ocean, so we have plenty of room for ocean activity there. I would hope that with further cost improvements and new technology, like floating turbines, this abundant resource can further enhance our state's energy supply. We are also seeing significant advances in technologies like marine and hydrokinetic (MHK) energy, an innovative form of hydropower that, I think, has historically been underutilized.

Back home, in Alaska, we have a jump-start on MHK with one of Ocean Renewable Power Company's (ORPC's) RivGen® facilities, which is now providing about half of the power for the rural Southwest village of Igiugig. More communities in the state are interested in marine hydrokinetic after seeing Igiugig's success. Again, I had an opportunity to go out several years ago to visit with the leadership there in Igiugig and understand what they were trying to do. It is pretty incredible when you think of what that small river turbine is able to contribute when you feed that into the small microgrid for this village that utilizes a wind turbine, a little bit of solar, and then harnessing the power of that river there.

Finally, we have alternative maritime shipping fuels as a focus area for this hearing. Last year, we had a hearing on the International Maritime Organization's (IMO) new sulfur standard, but one area we did not dive into was IMO's expected long-term carbon reduction goals and what the options really are for reducing emissions from shipping. A recent report from the International Energy Agency (IEA) found that there are opportunities in hydrogen, electricity, biofuels and even ammonia, but developing those options will require a lot of research and development going forward.

In addition to the technologies that are at the core focus of today's hearing, we have tremendous opportunities in methane hydrates from the seafloor as well as floating nuclear reactors that can be built more cheaply and move to where power is needed most. Coastal states have the opportunity to expand and reimagine their ocean-based economies with these technologies and there is plenty of space for the interior, non-coastal states to participate and to benefit by manufacturing equipment and producing similar fuels. Taken together, these technologies can help enable a broader blue economy that is either untethered or interconnected with inland energy facilities. Emerging drivers of economic growth like aquaculture, seabed mining and desalination will benefit from having directly coupled energy sources. Developing a broader range of offshore energy technologies will enable cleaner and more affordable energy for island communities and could even help recover from natural disasters.

To again turn it back home to Alaska, I see tremendous opportunities for these technologies, both individually and in a hybrid fashion. Take the community of Dutch Harbor in Alaska, out in the

Aleutians, for example. Imagine local communities drawing geothermal power from the Makushin Volcano. Imagine them producing hydrogen and more electricity from offshore wind and marine energy to power and refuel shipping vessels that are transiting between Asia and the Lower 48, and imagine floating data centers in Cook Inlet powered by naturally strong tides in the area. The possibilities are endless. If we expand research and development in each of these areas as authorized in our American Energy Innovation Act, we can make that vision a reality. And while it may appear unlikely right now, just remember that about 10 to 15 years ago, solar, onshore wind, and hydraulic fracturing all appeared to be small players in our energy economy and yet those technologies now dominate new electricity capacity investment here in this country.

We have a great panel with us this morning, well-equipped to cover both government and private sector activities for emerging forms of offshore energy. Our panel includes: Mr. Daniel Simmons, who is the Assistant Secretary for Energy Efficiency and Renewable Energy (EERE) at the Department of Energy (DOE); Dr. Walter Cruickshank, who is the Acting Director of the Bureau of Ocean Energy Management (BOEM) at the Department of the Interior (DOI); Mr. Stuart Davies, who is the CEO of the Ocean Renewable Power Company (ORPC); Ms. Siri Kindem, who is the President of Equinor Wind U.S.; and Mr. Jonathan Lewis, who is the Senior Counsel at the Clean Air Task Force.

I want to thank all of our panelists for joining us to discuss these technologies and our sustainable blue economy. I cannot think of a better time for this hearing or to pass our energy innovation bill through the Senate than National Clean Energy Week.

Senator Manchin, I turn to you for your comments and then we will get to this great panel.

STATEMENT OF HON. JOE MANCHIN III,
U.S. SENATOR FROM WEST VIRGINIA

Senator MANCHIN. Well, thank you, Chairman Murkowski. I look forward to today's hearing about ocean energy. It has been quite a while since West Virginia has had oceanfront property, but I am told it did happen. I want to thank you for convening the hearing on emerging ocean technologies.

As a boat owner and an avid boater, as all my colleagues in the Senate know, I take a special interest in the fuels part of today's conversation which I think will be most interesting. I appreciate our witnesses joining us to share your expertise with us and update us on the progress made in the technologies and the deployment of these technologies. I would like to take a moment to note the relevance of this topic to the work that Chairman Murkowski, the members of this Committee and that I have undertaken to advance the American Energy Innovation Act which we are very hopeful that we will still be successful very shortly.

Our energy package will advance climate solutions across the four sectors of the economy that make up approximately 90 percent of our current greenhouse gas emissions. Advancing marine renewable energy and offshore wind technologies is part of that solution as well as authorizing much needed research on the industrial

equipment needed to make the shipping fuels of the future. Included in that package are Senators Smith and Collins' Wind Energy Research and Development Act which covers both onshore and offshore wind energy research and development, and Senator Wyden's Marine Energy Research and Development Act which covers the full range of marine energy technologies. Those are just two examples of the important provisions in the energy bill, and I remain committed to working to help get that across the line with my Chairman.

Turning to the topic at hand, I am glad that for today's hearing we have both the perspective of the technology and project developers, including DOE's important research, development and demonstration role. And also, the agency charged with managing the federal permitting approval process, the Bureau of Ocean Energy Management. That is important because we need increasing and continued R&D for these growing and emerging technologies, but we also need to ensure that they can actually come online. I look forward to hearing from our witnesses about some of the barriers for these technologies, and I expect that we will hear robust discussion of how we can better align our national interests in developing these new energy sources and the industries behind them with the reality of the permitting challenges that you are going to face.

My good friend, Senator Whitehouse, joined us just last week to discuss his work on offshore wind, specifically relating to revenue sharing and revenue sharing is a big thing with most every Senator here because they are trying to basically support their home areas. Revenue sharing is not the topic of today, but I would be remiss not to mention that expanding offshore generation in federal waters is a revenue raiser. In addition, the technologies that we will be discussing today have the potential to create U.S. jobs for workers in communities that need a long-term lifeline. Our supply chains and manufacturing sector have struggled for decades causing hardship for steelworkers, shipbuilders, coal miners and many other hard-working men and women around the country. The Coronavirus has put those vulnerabilities in the spotlight, and it is making it clear how important targeted and enduring policies to correct those vulnerabilities will be. By identifying the policies and industries that will rebuild our manufacturing sector and reclaim our economic future, I believe that we can help our workers and their families while reestablishing U.S. leadership in existing and entirely new energy markets.

One final quick fact that I would like to share is that maritime freight shipping currently contributes approximately 12 percent of the U.S. greenhouse gas emissions. That is 12 percent by the shipping—slightly more than our agricultural sector—and shipping business is projected to triple in the next 30 years. I know that DOE is hard at work to help us meet the International Maritime Organization's reduced emissions goals, so I look forward to hearing about the research and development needs and opportunities for low-carbon maritime fuels.

With that, I appreciate all of you being here and those who are joining us virtually and look forward to the hearing.

Thank you, Madam Chairman.

The CHAIRMAN. Thank you, Senator Manchin.

With that, we will turn to our panel of witnesses. As I have introduced each of you previously, I will just repeat my welcome. Thank you for being here both in person and, for those that are with us online this morning, thank you as well. We will begin with our Assistant Secretary for DOE, the Honorable Daniel Simmons. We will go down the line in order of introduction. It would be Mr. Simmons, Dr. Cruickshank, Mr. Davies, Ms. Kindem and then Mr. Lewis. We would ask that you try to keep your comments to about five minutes. Your full statements will be incorporated as part of the record, and then we will have an opportunity for some questions and answers at the end.

With that, Assistant Secretary, if you would like to lead off and thank you again for being here.

STATEMENT OF HON. DANIEL R. SIMMONS, ASSISTANT SECRETARY, ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. SIMMONS. Thank you, Chairwoman Murkowski and Ranking Member Manchin. Thank you for the opportunity to testify on the development and deployment of emerging offshore energy technologies. My name is Daniel Simmons, and I am the Assistant Secretary for the Office of Energy Efficiency and Renewable Energy (EERE).

Developing technologies that tap into our abundant offshore energy resources play a vital role in the Department's all-of-the-above energy strategy with more than 50 percent of the population living within 50 miles of coastlines, and the coastal and Great Lakes states accounting for nearly 80 percent of U.S. electricity demand, there is vast potential for clean, renewable electricity to communities and cities across the United States using innovative technologies such as offshore wind, marine and hydrokinetic (MHK) technologies, and alternative sources of drop-in fuels for marine shipping applications. While EERE works to overcome the technological barriers to these emerging technologies, there are other barriers such as permitting and regulations that fall outside the scope of the Department of Energy but can slow the innovation and deployment of emerging offshore energy technologies. Streamlining permitting is an important aspect to helping drive forward this important innovation and development of offshore energy technologies.

Offshore wind is poised to become one of the fastest-growing areas or the fastest-growing area of renewable energy development in the next decade. The unique coastal and ocean environment in the United States includes deep water, hurricanes, and icing and it further requires innovations to realize low-cost installation of wind in these regions. EERE's Wind Energy Technologies Office currently funds two Offshore Wind Advanced Technology Demonstration Projects that are seeking to overcome these challenges. One of the projects is located in deep water off the coast of Maine and is positioned to be the first U.S. floating wind project using commercial technology. The Wind Office also conducts cross-cutting research to bring down the cost of both offshore and onshore applications of wind energy technologies such as advanced technologies for ultra-large and ultra-lightweight turbines.

Another offshore energy technology with untapped potential, as the Chairwoman remarked earlier, is marine and hydrokinetic resources, also called MHK. EERE's Water Power Technologies Office leads the way in evaluating new sources of MHK energy, including waves, currents, tides, and ocean thermal resources. EERE, through both the Wind and the Water Offices, supports capabilities at the Pacific Northwest National Laboratory's Marine and Coastal Science Research Laboratory which stands at the intersection of the blue economy and energy innovation and supports key elements of the Water Office's Powering the Blue Economy initiative which we also call PBE. The Powering the Blue Economy initiative supports marine energy R&D targeting maritime markets that could benefit from the early adoption of ocean energy technologies. This initiative offers the potential to accelerate cost reductions from grid-scale marine energy systems. It can also accelerate offshore energy development by enabling critical support technologies such as monitoring systems for offshore oil and gas wells or providing persistent power needed for underwater vehicles to inspect wind turbine foundations. The Powering the Blue Economy initiative also focuses on providing support for resilient coastal communities by advancing marine energy's potential to power remote, coastal and island grids.

In addition to researching innovative ways to use offshore resources to provide electricity, EERE's Bioenergy Technologies Office and Hydrogen and Fuel Cell Technologies Offices are looking at other energy options. The Bioenergy Technologies Office is examining the potential for bio-derived marine fuels that are low-sulfur by their very nature, and Oak Ridge National Laboratory recently released a report titled, "Understanding the Opportunities for Biofuels for Marine Shipping." Additionally, the Hydrogen and Fuel Cell Technologies Office is collaborating with the Wind Office through the H2@Scale initiative which envisions affordable hydrogen production, storage, distribution and use across multiple sectors in the economy and is funding activities to demonstrate the potential of hydrogen for maritime applications, including using hydrogen for energy storage powered by offshore wind and looking at hydrogen fuel cells that can power marine vessels.

I look forward to working with you to promote affordable and reliable energy to enhance America's economic growth and energy security. Thank you for the opportunity to appear before the Committee today. I look forward to your questions and hearing from the other panelists.

Thank you very much.

[The prepared statement of Mr. Simmons follows:]

Testimony for the Record

The Honorable Daniel R Simmons

Assistant Secretary
Energy Efficiency and Renewable Energy

FOR A HEARING ON

Development and Deployment of Emerging Offshore Energy Technologies.

BEFORE THE
UNITED STATES SENATE
ENERGY AND NATURAL RESOURCES COMMITTEE

Tuesday, September 22, 2020
Washington, D.C.

Introduction

Chairwoman Murkowski and Ranking Member Manchin, thank you for the opportunity to testify before the committee today.

As the Assistant Secretary of the Office of Energy Efficiency and Renewable Energy (EERE), I oversee a broad portfolio of renewable energy, energy efficiency, and transportation programs. Our program's primary focus is on funding technology research and development through competitive solicitations open to the public as well as management and operations contracts with the National Laboratories, which play a central role in advancing America's leadership in scientific research and development. The knowledge generated by EERE research and development drives down the costs of new technologies, supporting the efforts of U.S. industries, businesses, and entrepreneurs in deploying innovative energy technologies.

Developing technologies that tap into our abundant offshore energy resources play a vital role within the Administration's American energy strategy. With more than 50% of the population living within 50 miles of coastlines, and the coastal and Great Lakes states accounting for nearly 80% of U.S. electricity demand, there is vast potential to provide clean, renewable electricity to communities and cities across the United States using innovative technologies such as offshore wind, marine and hydrokinetic (MHK) technologies, and alternative sources of drop-in fuels for marine shipping applications.

While EERE works on overcoming the technological barriers to these emerging technologies, there are other considerations, such as permitting, that fall outside of the scope of the Department of Energy, that but can hinder the innovation and deployment of emerging offshore energy technologies. There are also increased technical challenges to working in the marine environment, and this can translate into delayed feedback and development of new innovations.

Affordable, reliable energy gives Americans the competitive edge needed to excel in the rapidly changing global energy economy. I am excited to talk with you today about our activities promoting innovation in the offshore energy industry.

Innovations in Offshore Wind Energy

Coastal load centers have a technical offshore wind resource potential twice as large as the nation's current electricity use. With such an enormous untapped potential, coastal states are increasingly looking to offshore wind as a way to provide clean, reliable electricity and to meet their renewable goals. According to the National Renewable Energy Laboratory, the United States had 28.5 GW of offshore wind in the development pipeline at the end of 2019. In the next two decades, offshore wind has the potential to provide power to the East and West Coasts, Great Lakes, Gulf of Mexico, Alaska, and Hawaii by utilizing both fixed-bottom and floating offshore wind technologies.

Because offshore wind energy is poised to become one of the fastest-growing areas of renewable energy development in the next decade, EERE is driving innovation to ensure the affordability

and reliability of this technology. The unique coastal and ocean environment in the U.S., which includes deep water and hurricanes, requires further innovations to realize low-cost installation of wind in these regions. EERE's Wind Energy Technologies Office has two active Offshore Wind Advanced Technology Demonstration Projects, one of which is located off the coast of Maine and is positioned to be the first U.S. floating wind project using commercial technology.

EERE also funds the National Offshore Wind Research & Development Consortium to conduct research and development activities to address technological barriers and lower the costs and risks of offshore wind in the United States. Last month, the Consortium issued its second Request for Proposals (RFP) for additional industry-prioritized offshore wind research and development topics that targeted the areas of large-scale wind turbines, support structure innovation, supply chain development, electrical systems innovation, and technology solutions to mitigate conflicts caused by competing uses of the ocean space. In their first RFP, the Consortium selected 20 awards totaling $17.3 million..[1] The Wind Energy Technologies Office (WETO) works closely with the Consortium to develop their RFP, review proposals, and recommend projects for award to maximize the impact of federal funding.

WETO also conducts cross-cutting research that has the potential to bring down costs in both offshore and land-based applications of wind energy technologies. Those cross-cutting research activities include advanced technologies for ultra-large, ultra-lightweight turbines, breakthroughs in ultra-large blade manufacturing, improved energy forecasting and plant optimization, and autonomous inspection and maintenance systems. To gain a better understanding of the scale of these technologies, GE's Haliade X 12-megawatt and Siemens' 14-megawatt offshore wind turbines stand approximately 260 meters tall and feature blades that are over 100 meters long.

Finally, WETO invests in research and development to develop technical solutions to siting and permitting challenges, including research aimed at informing and developing technical solutions to issues associated with wind turbine radar interference and impacts on wildlife. The office is currently supporting the development of a suite of advanced tools for automated monitoring of impacts of offshore wind on bird and whale species.

Innovations in Marine and Hydrokinetic (MHK) Energy

DOE studies have found that marine and hydrokinetic resources across the U.S. have technical potentials that equate to roughly 30-40% of the nation's electricity load, though these resources differ significantly by region: for example much of the wave resource is on the West Coast, with half in Alaska alone, while the ocean current resource is located in the Southeastern states bordering the Gulf Stream..[2] Wave energy makes up about two-thirds of this opportunity, and it is abundant across all five Pacific states. Tidal, ocean current, and river current resources comprise most of the remaining potential, and they are concentrated, but geographically diverse

[1] https://www.energy.gov/eere/wind/articles/national-offshore-wind-rd-consortium-issues-second-request-proposals
[2] https://www.energy.gov/eere/water/marine-and-hydrokinetic-resource-assessment-and-characterization

resources. These resources range from tidal hotspots in Alaska, the Pacific Northwest and the Northeast to the Gulf Stream that stretches from south Florida to the Outer Banks.

EERE's Water Power Technologies Office (WPTO) leads the way in evaluating new sources of marine and hydrokinetic (MHK) energy, including waves, currents, tides, and ocean thermal resources. The U.S. is one of the global leaders of this new and innovative industry, with more than 75 companies (representing better than a third of all active marine energy companies operating globally) and 150 research organizations working in marine energy research. Marine and hydrokinetic technologies are not yet cost competitive with other sources of bulk power. This is predominantly due to unique engineering challenges of harnessing power from free-flowing water and the cost and time it takes to test and innovate new technologies in the ocean, where single tests can take over a year and any mistake can result in a sunk investment. DOE addresses these challenges in multiple ways: advancing critical early-stage research that sets the technical foundation for all technologies and entrepreneurs; providing direct support to American innovators to design new MHK systems and test them at all scales; and providing access to dedicated infrastructure where devices can be tested quickly, reliably, and cost-effectively, and where lessons learned can be efficiently transferred to the next generation of designs.

In addition to supporting the early-stage R&D that will enable long-term cost reductions and performance improvements, WPTO has also recently undertaken new efforts to explore nearer-term opportunities for marine energy to reduce power constraints for other ocean industries and remote communities with high energy costs.

WPTO launched its Powering the Blue Economy (PBE) Initiative in FY 2019, which supports marine energy R&D targeting maritime markets that could benefit from the early adoption of ocean energy technologies. PBE offers the potential to meaningfully accelerate cost reductions for grid-scale marine energy systems by both providing more opportunities for in-water experience and the potential of attracting additional private capital. The PBE initiative also can accelerate offshore energy development by enabling critical support technologies, such as monitoring systems for offshore oil and gas wells or providing the persistent power needed for underwater vehicles to inspect wind turbine foundations.

In FY 2020, WPTO built on its 2019 analysis and expanded the PBE portfolio to include attracting new universities and solvers through new competitive funding opportunities, investing in foundational research at the national labs, and launching new partnerships and programs within DOE and with federal partners. In 2020, WPTO launched a joint Ocean Observing Prize with the National Oceanic and Atmospheric Administration to generate innovation in marine energy-powered ocean observing platforms. The newest round of the prize is focused on powering solutions for hurricane monitoring at sea.

In July, WPTO announced the winners of the first ever Marine Energy Collegiate Competition. This was the first year of the competition, which is managed by the National Renewable Energy Laboratory on behalf of WPTO. WPTO is now accepting applications of interest for the 2021 competition.

Innovations in Drop-in Fuels Applications for Marine Shipping

Global marine fuel consumption is estimated to be around 330 million metric tons (87 billion gallons) annually (mostly heavy fuels oils) and is expected to double in the next 20 years[3]. The marine shipping sector carries over 80% of global international trade and the sector is one of the single largest consumers of petroleum fuels, especially residual heavy fuel oil (HFO)[3]. Consequently, marine engines are one of the largest emitters of air pollutants. Higher fuel costs, emission regulations, and the additional processing accompanying HFO, may provide a new market opportunity for biofuels, many of which have low sulfur content and are being explored in DOE's Bioenergy Technologies Office (BETO) and Hydrogen and Fuel Cell Technologies Office (HFTO).

BETO has been developing broad capabilities to convert domestic biomass and waste resources into fuels, products, and power to enable affordable energy, economic growth, and innovation in renewable energy and chemicals production. BETO commissioned a multi-laboratory effort to outline these opportunities, challenges, and research needs for marine application, which resulted in the publication of *Understanding the Opportunities of Biofuels for Marine Shipping* by Oak Ridge National Laboratory in December 2018.

Specific conversion pathways under development within BETO's program include pyrolysis, gasification with synthesis gas upgrading, hydro-thermal liquefaction, and biochemical conversion technologies and offer a range of choices for this sector. Hydrothermal liquefaction and fast pyrolysis produce a range of molecules with different combustion properties, including fractions that are amenable for marine fuel applications, either as straight drop-ins or in blends. These fuels contain negligible amounts of sulfur, and are also of interest as a heating oil in the Northeast. BETO is also investigating the scalability of potential biofuel pathways to ensure solutions not only look at the fuel itself, but the entire supply chain to obtain meaningful quantities of these fuels near refuel port cities.

In addition, HFTO is collaborating with WETO through the H2@scale initiative, which envisions affordable hydrogen production, storage, distribution and use across multiple sectors in the economy. A component of the H2@scale vision leverages hydrogen as an enabler to renewable energy, such as solar and wind, including integration with baseload power based on fossil and nuclear energy. For example, by producing hydrogen when power generation exceeds load, electrolyzers, which use electricity and water as input to produce hydrogen, can prevent curtailment of solar and wind, and support grid stability. Through the H2@Scale initiative, HFTO is funding activities to demonstrate the potential of hydrogen in maritime applications.

HFTO also recently released a Request for Information, which closed September 15, 2020.[4], in which we expect stakeholder input on topics such as large-scale storage that could be applicable for either onboard fuel or hydrogen transport by marine vessels.

[3] https://www.osti.gov/biblio/1490575-understanding-opportunities-biofuels-marine-shipping
[4] https://eere-exchange.energy.gov/Default.aspx#Foald9fd3296a-81af-4d17-953b-82f7f5e9718c

Lastly, the Vehicle Technologies Office's battery and electrification R&D are applicable to activities associated with marine electrification that are focused on shorter distance travel such as electric passenger ferries. Washington State Ferries, the largest ferry system in the U.S., are looking at new hybrid-electric 'Olympic Class' ferries capable of carrying 144 cars and 1,500 passengers each in all-electric mode or with a hybrid mode backup. Charging will take place at ferry terminals to maximize the battery-operation. In 2019, Norway had seventeen battery electric ferries in use servicing the inner parts of the Oslofjord. EERE will continue to track the progress of these deployments.

Conclusion

Today the U.S. is producing more affordable and cleaner energy from a wider range of resources than ever before. EERE's investments have advanced America's leadership in the development of emerging offshore energy technologies.

I look forward to working with you to provide American families and businesses with a wider range of energy and mobility options for continuing affordability, reliability, and security of our nation's energy.

Thank you for the opportunity to appear before the Committee today. I look forward to your questions.

The CHAIRMAN. Thank you, Assistant Secretary Simmons.

We will now turn to Dr. Walter Cruickshank with the Department of the Interior.

STATEMENT OF DR. WALTER CRUICKSHANK, ACTING DIRECTOR, BUREAU OF OCEAN ENERGY MANAGEMENT, U.S. DEPARTMENT OF THE INTERIOR

Dr. CRUICKSHANK. Chairman Murkowski, Ranking Member Manchin, members of the Committee, I am pleased to appear before you today to discuss the Bureau of Ocean Energy Management's role in developing America's emerging energy resources on the Outer Continental Shelf (OCS). BOEM is responsible for managing the development of our nation's offshore energy and mineral resources in an economically and environmentally responsible manner. BOEM plays an important role in advancing the Administration's comprehensive approach to expanding responsible, domestic energy development as part of a broader effort to secure the nation's energy future, benefit the economy and create jobs.

I would like to address three emerging offshore energy resources today: wind, marine hydrokinetic energy and methane hydrates.

BOEM works diligently to oversee the responsible offshore wind development on the OCS by identifying wind energy areas using a transparent process with extensive environmental analysis, stakeholder outreach and public participation. BOEM is committed to working with all our stakeholders—including state and local governments, the military, other federal agencies, the fishing and maritime communities, federally-recognized tribes and the offshore wind industry—to ensure any potential development that takes all ocean uses into account. And once that's a partnership, the Department of Energy's National Renewable Energy Laboratory has provided invaluable insight to BOEM by providing wind resource assessments for offshore areas of the United States. To date, BOEM has issued 16 active commercial offshore wind energy leases, generating over $470 million in bonus bids for 1.7 million acres. We have at least one wind energy lease off every state on the Atlantic Coast from Massachusetts to North Carolina, and we're examining additional offshore wind planning activities in the Atlantic and Pacific OCS.

BOEM has received ten Construction and Operations Plans (COPs) for specific wind energy projects in areas that have already been leased, and we anticipate receiving up to five more COPs over the coming year. The first wind turbines in federal waters were installed offshore of Virginia in June of this year. Continued technological development will be important to the industry's future, including drawing competitiveness of floating foundations for wind turbines that would be necessary for offshore wind development in the Pacific. Other technological areas of importance include shared offshore transmission systems and grid integration as well as technologies that will mitigate impacts on the environment and other uses of the ocean.

BOEM is committed to advancing innovative technologies for both wind energy and marine hydrokinetic energy offshore of the United States. MHK technology harnesses energy from ocean waves, tides and currents and converts it into electricity to power

our homes, buildings and cities. Jurisdiction for grid-connected MHK projects on the OCS is shared by BOEM and the Federal Energy Regulatory Commission (FERC). BOEM has authority to issue leases, and FERC has authority to issue licenses for the construction and operation of MHK projects on those leases. We are excited for the possibilities these two new technologies bring and expect to learn more as projects develop.

Turning to methane hydrates, over the past several years, BOEM has made significant advances in our effort to assess resource potential of gas hydrates located on the OCS. Gas hydrates are ice-like substances occurring in nature where a solid water lattice accommodates gas molecules in a cage-like structure. These form under conditions of relatively high pressure and low temperatures such as those found in the shallow subsurface under many of the world's deepwater oceans. One cubic foot of hydrate at reservoir temperature and pressure yields approximately 160 cubic feet of gas at atmospheric temperature and pressure, and the amount of natural gas contained in methane hydrates worldwide is estimated to be far greater than the entire world's conventional natural gas resources.

BOEM, in cooperation with the U.S. Geological Survey, the Department of Energy and other agencies, is working to develop models to identify resources on the OCS. The technology for production of hydrates is in its infancy and sustained production of energy from gas hydrates has yet to be demonstrated. Nevertheless, BOEM continues to work with partners to create and adapt models of marine hydrate resources for all regions of the OCS to better understand the potential viability of our nation's gas hydrate resources. Development of emerging offshore energy resources advances the Administration's goal of expanding domestic energy production to support our nation's long-term economic development. Offshore energy in all its forms will play an important role in the country's energy portfolio and BOEM stands ready to work with the Committee as we move forward.

I look forward to our continuing to work together and to answering your questions. Thank you.

[The prepared statement of Dr. Cruickshank follows:]

Walter Cruickshank

Acting Director

Bureau of Ocean Energy Management

U.S. Department of the Interior

Before the

Senate Energy and Natural Resources Committee

September 22, 2020

Chairman Murkowski, Ranking Member Manchin and members of the Committee, I am pleased to appear before you today to discuss BOEM's role in developing America's emerging energy resources on the Outer Continental Shelf.

My name is Walter Cruickshank and I am the Acting Director of the Bureau of Ocean Energy Management (BOEM). BOEM is responsible for managing the development of our Nation's offshore energy and mineral resources in an economically and environmentally responsible manner. BOEM accomplishes this mission through its oil and gas, renewable energy, and marine minerals programs, all of which are guided by rigorous, science-based environmental review and analysis. BOEM helps support the Administration's goal to increase domestic energy production by providing access to Outer Continental Shelf (OCS) resources through programs that enable exploration and production of offshore oil and gas resources and facilitate renewable energy development. As a result, BOEM plays an important role in advancing the Administration's comprehensive approach to expanding responsible domestic energy development as part of a broader effort to secure the Nation's energy future, benefit the economy, and create jobs.

A hallmark of BOEM's approach to offshore energy development is striking the right balance to protect our coasts and communities while still allowing the United States to remain a global energy leader.

Wind

BOEM works diligently to oversee responsible offshore wind development along the OCS by identifying wind energy areas, using a transparent leasing process with extensive environmental analysis, stakeholder outreach and public participation. BOEM is committed to working with all our stakeholders – which includes state and local governments, the U.S. military, other federal government agencies, fishing and maritime communities, federally recognized Tribes, and the offshore wind industry – to ensure any potential development takes all ocean uses into account. BOEM coordinates OCS renewable energy activities with its federal, state, local, and tribal government partners through mechanisms such as Intergovernmental Renewable Energy Task Forces for each interested State and partnerships, such as a partnership with the Department of Energy's National Renewable Energy Laboratory, which provided invaluable insight to BOEM by providing the 2016 Wind Resource Assessments for the United States. BOEM also

coordinates public information meetings to help keep interested stakeholders updated on major renewable energy milestones.

To date, BOEM has issued 16 active commercial offshore wind energy leases generating over $470 million in bonus bids for 1.7 million acres.

BOEM's Offshore Renewable Energy Program has issued at least one wind energy lease off every state on the Atlantic Coast from Massachusetts to North Carolina. We are examining additional offshore wind planning activities in the Gulf of Maine, the New York Bight, North Carolina, California, Hawaii and Oregon. BOEM has approved 10 Site Assessment Plans (SAPs) and received 10 Construction and Operations Plans (COPs) for specific Atlantic wind energy projects in areas that have already been leased and anticipates receiving up to five more COPs over the next year. We also note that the first wind turbines in Federal waters were installed offshore Virginia in June 2020.

In addition, BOEM is in the planning stages for areas offshore the Pacific Coast as well, including working with partners in the States of California, Oregon, and Hawaii.

Marine Hydrokinetic

BOEM is committed to advancing innovative technologies for both wind and marine hydrokinetic energy offshore the United States. Marine hydrokinetic (MHK) technology harnesses energy from ocean waves, tides and currents, and converts it into electricity to power our homes, buildings and cities. Jurisdiction for grid connected MHK projects on the OCS is shared by BOEM and the Federal Energy Regulatory Commission (FERC). BOEM has authority to issue leases, easements, and rights-of way and FERC has authority to issue licenses for the construction and operations of MHK projects on the OCS. Lease issuance by BOEM is a prerequisite for a license from FERC.

We are excited for the possibilities these new technologies bring and expect to learn more as projects develop.

Marine Hydrates

Over the course of the past several years, BOEM has made significant advances in our effort to assess the resource potential of gas hydrates located on the floor of the OCS. Gas hydrates are ice-like crystalline substances occurring in nature where a solid water lattice accommodates gas molecules (primarily methane, the major component of natural gas) in a cage-like structure. These form under conditions of relatively high pressure and low temperatures, such as those found in the shallow subsurface under many of the world's deep-water oceans. One cubic foot of hydrate at reservoir temperature and pressure yields approximately 160 cubic feet of gas at atmospheric temperature and pressure. The amount of natural gas in methane hydrates worldwide is estimated to be far greater than the entire world's conventional natural gas resources.

BOEM, in cooperation with the United States Geological Survey, the Department of Energy, and other government agencies, is working to research and develop models that would identify resource locations and quantities on the OCS. The technology that would recover hydrates for energy production is in its infancy, and the sustained production of energy from gas hydrates has yet to be demonstrated anywhere in the world. Nevertheless, BOEM continues to work with both its public and private partners to create and adapt models of marine hydrate resources for all four regions of the OCS to better understand the potential viability of our nation's gas hydrate resources.

Conclusion

An energy strategy that advances the Administration's goal of expanding domestic energy production includes the development of the emerging offshore energy resources that have a role in our Nation's long-term economic development. These resources include wind, marine hydrokinetic energy, and the potential recovery of gas hydrates from the ocean floor. Securing these sources of energy creates American jobs and promotes innovation in the United States.

Offshore energy, in all its forms, will play an important role in this country's energy portfolio, and BOEM stands ready to work with the Committee as we move ahead. I look forward to our continued work together and to answering your questions today.

The CHAIRMAN. Dr. Cruickshank, thank you so much.

We now turn to Mr. Stuart Davies, who is with ORPC. Welcome to the Committee.

STATEMENT OF STUART DAVIES, CHIEF EXECUTIVE OFFICER, OCEAN RENEWABLE POWER COMPANY, INC.

Mr. DAVIES. Good morning, my name is Stuart Davies, CEO of the Ocean Renewable Power Company based in Portland, Maine. It's an honor to speak with you today, and I want to thank you for your invitation.

Prior to joining ORPC I spent 17 years at Sankaty Advisors, a $35 billion asset management firm where I was both a member of the Executive and the Investment Committees. During my career I spent a lot of time studying fossil fuel and renewable energy companies as well as utilities. In 2016 I left to work with companies that were trying to solve big challenges. I was attracted to ORPC due to its leadership position in river and hydro and tidal energy solutions. Over the past few years, I came to believe that the U.S. and world cannot transition to 100 percent renewable power without developing river and tidal energy technologies or marine and hydrokinetics, MHK, as they are called by the Department of Energy.

Wind, solar and battery storage are great sources of renewable energy, but we need a highly predictable, baseload energy source to pair up with these technologies to get to 100 percent. River and tidal energy meet these criteria. Importantly, they have no land use issues, no noise issues, no visual impact and low environmental impact. With the right support over the next five to ten years, MHK technology can grow rapidly to meet our renewable energy objectives, providing power to over 100 million people, and in the process creating hundreds of thousands of new manufacturing, engineering and marine industry jobs.

ORPC is a great example of U.S. MHK companies whose devices are at or near commercialization and are refining their technologies to drive down the cost of energy. Our RivGen® Power System has been operating for the past ten months in Igiugig, Alaska, providing clean, locally-produced renewable electricity generated from the Kvichak River and displacing very high cost diesel-generated power. ORPC has proven that the RivGen® can survive the harsh winter conditions in a remote community in Alaska and continues to provide power daily to this community. ORPC is deploying the same core technology in the tidal environment of False Pass, Alaska, which, like Igiugig, is representative of remote isolated grid communities that pay five to ten times as much for electricity as the average American. ORPC's devices could also be exported to countries around the world where roughly 1.5 billion people currently live near ocean or river resources who are without power or use diesel generators as their sources of electricity. ORPC is also planning a project in Eastport, Maine, that could be another model for the future, as it will combine tidal energy with solar, battery storage and a smart microgrid to provide 100 percent locally-produced renewable energy in that community.

What does the industry need to do over the next five years? It needs to reduce its cost of energy to increase market adoption.

Wind and solar are currently below $0.10 per kilowatt hour, but given that tidal and river energy can provide baseload power, if MHK technology can provide power in the $0.15 to $0.20 range, it will be a viable source of electricity. In the past decade, the wind and solar industries received approximately $75 billion in federal and state funding and tax incentives. That financial support was highly successful in accelerating cost reductions. These industries have created over 500,000 jobs, and they continue a high growth trajectory in terms of their share of energy production. Meanwhile, MHK received about $75 million over that time period, roughly a tenth of a penny on a relative basis. With equitable future support, MHK has the opportunity to experience the same rapid cost reduction.

What policy changes can help this happen? First, provide infrastructure funding to support communities to install river and tidal power systems. Our target early adopter communities have high power costs and do not have the economic resources to purchase these systems. Infrastructure funding would provide them with cheaper power and with it, its related economic benefits. Second, streamline the regulatory process. A review of MHK pilot projects in state waters licensed by the FERC shows that the average time to obtain approval is 7.5 years. This timeframe is simply too long for the commercialization of mature MHK devices. Finally, the Title 17 Innovative Energy Loan Guarantee Program, a $25 billion investment tool, must be changed to help fund smaller projects. River and tidal projects perfectly match the program's loan criteria and goals, but the diligence and approval process add roughly $1.5 million to projects costing between $2 and $10 million. We propose that Congress simply carve out approximately two percent of the program to create a $500 million fund for smaller projects that have much less stringent diligence and approval criteria.

In conclusion, the last ten years was the decade of solar and wind. With the right incentives in place, the next ten years could be the decade of river and tidal energy bringing with it manufacturing and marine industry jobs to communities across the country and creating a highly predictable, baseload renewable energy source that will move the U.S. and the world closer to a 100 percent renewable energy future.

Thank you again for allowing me to speak today, and thank you for your time.

[The prepared statement of Mr. Davies follows:]

POLICY BRIEF

Senate Energy and Natural Resources Committee Hearing on Offshore Energy Technologies

September 22, 2020
Official Testimony from Stuart Davies, CEO, ORPC, Inc.

Executive Summary

The marine hydrokinetic (MHK) energy industry, powered by river and tidal currents, is an essential element in the global energy transformation and has the ability to become the third component, along with wind and solar, of a 100 percent renewable energy future. Targeted government policies, including infrastructure investment and renewable energy loan programs, can help these technologies accelerate growth and create thousands of new manufacturing and marine industry jobs in the process. Given the river and tidal resources available in the U.S., the country should develop a network of smart microgrids that combine MHK as baseload power supply with wind, solar and battery storage to provide a fully renewable energy solution. This infrastructure would give local communities control over their power supply, increase the U.S. electricity grids reliability and security, and dramatically reduce greenhouse gas emissions helping the U.S. achieve its climate change goals. Regulatory policy will need to be adjusted to accelerate the installation of devices that are needed for renewable energy growth.

Introduction

Achieving a 100 percent clean energy economy and net-zero emissions, along with its attendant sustainable economic development through job creation, are important goals in currently proposed climate change plans. But to avoid the worst consequences of climate change, an aggressive renewable energy solution must be the path taken to reduce CO2 emissions. Solar and wind have made significant reductions in CO2 emissions over the past decade, but this provides an incomplete picture. The most transformative solution is smart microgrid technology that uses MHK energy from tides and rivers as a baseload resource with wind/solar/battery storage as a necessary complement. This is technically possible.

In recent years, historic transformative plans have been developed to address climate change and local air pollution. The Green New Deal, for example, is a 2019 congressional resolution that calls for a 10-year mobilization plan that would achieve 100 percent clean energy to supply all U.S. power. Other plans call for 100 percent clean energy economy and net-zero emissions no later than 2050. However aspirational these goals are, components of the plans are not consistent with what leading industry players indicate are possible and therefore will fall short of meeting targeted goals. At a recent renewable energy conference, the CEO's of the market leaders in wind, solar and hydropower shared their vision for 2030 and forecasted that renewable energy would meet 50 percent of the electricity demand despite a five-fold increase in energy storage. This forecast did not predict any shift in industrial or transportation emissions, which comprise 50 percent of U.S. energy needs (Figure 1).[1]

[1] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

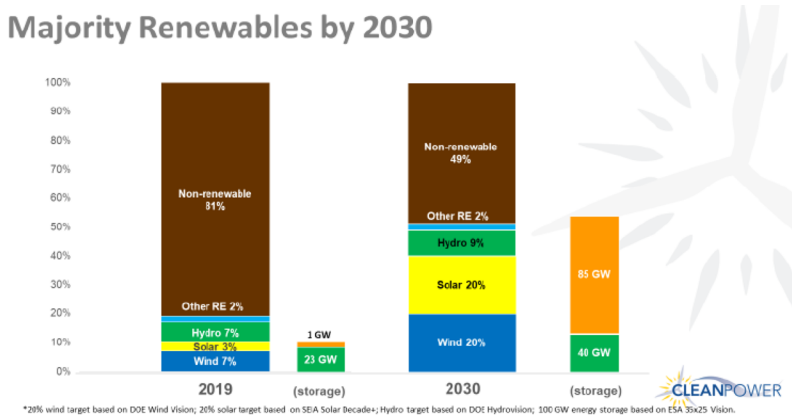


Figure 1. Forecast of majority renewables by 2030. Source: American Wind Energy Association, CLEANPOWER

As these technologies continue to mature, local communities will more and more be faced with land use and siting issues and be forced to make choices between arable land, housing stock, and renewable energy capacity. To truly unlock the potential growth and limit the land area required for wind and solar technology, the U.S. needs a baseload resource to pair with wind and solar that has no land use issues. New waterpower technologies (tidal and river) can provide that solution. With significant socio-economic benefits, favorable economic policies, scalable technology, and enabling regulatory policy, a transformative achievement can be made.

Background on the Marine Hydrokinetic Energy Industry

MHK energy is a promising yet underrepresented piece of the renewable energy sector, which offers high predictability and energy diversification. Roughly 40 percent of the world's population lives within 100 kilometers of the ocean,[2] and 6.5 percent of the world's population live in close proximity (median distance = 3 km) to a large river.[3] It is generally acknowledged that tidal current resources can be found in straits (e.g., Johnstone Strait, Canada; Pentland Firth, Scotland; Sound of Islay, Scotland; and Cook Strait, New Zealand), off of headlands (e.g., the Anglesey Skerries, Wales), in bays (e.g., Cook Inlet, Alaska; Western Passage, Maine; Minas Passage in the Bay of Fundy, Canada; and River Severn, UK), or between islands and landmasses (e.g., Rathlin Island, Ireland) where the coastal geometry helps to enhance the tidal currents.[4] River currents as a suitable resource are well-documented in the U.S.,[5] Canada,[6] and portions of South America.[7]

[2] https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf

[3] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3110782/#s3

[4] Borthwick, A, G.L, Marine Renewable Energy Seascape, 2016. Engineering 2 (2016) 69–78.

[5] Electric Power Research Institute, Assessment and Mapping of the Riverine Hydrokinetic Resource in the Continental United States, 2013

[6] Natural Resources Canada, Assessment of Canada's Hydrokinetic Power Potential, Phase 2 Report, 2011

[7] Inter-American Development Bank, Preliminary Analysis of Potential for River Hydrokinetic Energy Technologies in the Amazon Basin, 2015

Significant river and tidal capacity exist across North and South America, Europe, and East Asia-Pacific. In the U.S., riverine hydrokinetic technologies have the potential to provide a significant low-carbon energy supply contribution for many regions. A 2012 study suggests that theoretical recoverable energy potential is estimated to be 1,381 TWh per year.[8] For context, approximately 90,000 homes can be powered by 1 TWh of electricity generation each year.[9] Tidal energy resources in the U.S. are clustered in southern Alaska, sections of the northeastern coast, and in Washington. In 2018, the National Renewable Energy Laboratory published a study that put the U.S. tidal resource at 445 TWh per year, resulting in a total tidal and river resource potential to provide power to up to 150 million Americans.[10]

There are a number of companies that are active in the river and tidal hydrokinetics with MHK devices, many that are at or near commercialization. These companies have spent the past decade refining their technologies, and the industry has reached the milestone where it needs to deploy devices in the water. Once early solar and wind deployments demonstrated to the market their reliability and resiliency, utilities, homeowners, and businesses began installing these systems. More importantly, the financial markets gained confidence in the technology and increasingly cheap and abundant capital flowed into the sector driving the rapid adoption that we have experienced over the past 10 years. Policy initiatives that support MHK device deployment will unlock the potential for a similar cycle to repeat for tidal and river power.

ORPC, Inc., a Maine-based company, is included among this group and develops MHK power systems combined with smart microgrid technology to turn local river and tidal currents into a comprehensive baseload-renewable energy solution for both remote off-grid communities and urban communities. The RivGen® Power System has been operating for the past ten months in Igiugig, Alaska (Figure 2). It has proven it can survive harsh winter conditions in a remote community in Alaska, has received its scheduled summer maintenance, and is back on the bottom of the river providing power again to the community.

ORPC is using the same core technology in its TidGen®-80 device for tidal locations. ORPC is currently working on projects to deploy tidal devices in False Pass, Alaska, and Eastport, Maine. Both Igiugig and False Pass are representative of a number of remote communities that pay five to ten times as much for electricity as the average American, so developing projects like these not only adds renewable energy capacity, but it also provides the opportunity for economic growth through lower energy costs, as well as jobs.

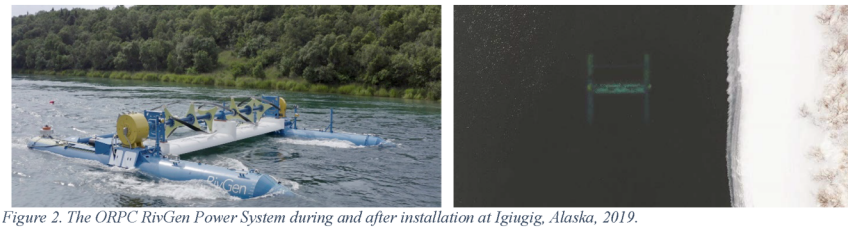


Figure 2. The ORPC RivGen Power System during and after installation at Igiugig, Alaska, 2019.

[8] Electric Power Research Institute: *Riverine Hydrokinetic Resource Assessment and Mapping,* 2012

[9] United States Department of Energy: *Quadrennial Technology Review*, 2015

[10] Marine Hydrokinetic Energy Site Identification and Ranking Methodology Pat II: Tidal Energy. NREL 2018.

ORPC's proposed project in Eastport, Maine, stands to serve as a model for a renewable energy future as it will combine tidal energy with solar, battery storage, and a smart microgrid to provide a 100 percent renewable energy solution for the community of Eastport.

Almost 700 million people globally use diesel generators for electricity, and there were about 789 million people in 2018 without access to electricity.[11] Many of these people live near ocean or river resources, so the solutions in Igiugig and Eastport could be a model around the world. This approach could develop into a major export for U.S. manufacturing over the next 20 years and create high-paying manufacturing jobs as the market grows.

In addition to remote communities, regions like Alaska are well positioned for utility-scale MHK to power regional grids and provide a renewable baseload power source for the future electrification of infrastructure. The Cook Inlet tidal energy resource has the potential to power 100 percent of the Alaskan economy (Figure 3). Industries looking for predictable baseload renewable resources to drive electrification include transportation, shipping, underwater data centers as well as defense and oil and gas facilities. These applications can be part of Alaska's economic opportunity as the gateway to the Northwest Passage. These are also applicable to other states with MHK resources, located on coasts (e.g., Alaska, Maine, and Washington) and inland (e.g., Idaho, Louisiana, Ohio, Missouri, Mississippi, Colorado, Tennessee, and West Virginia).

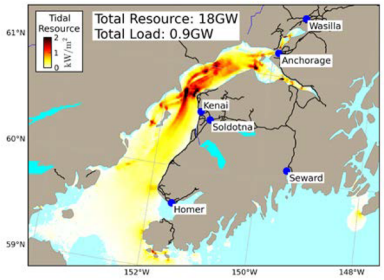


Figure 3. Tidal resource for Cook Inlet, Alaska. Source: National Renewable Energy Laboratory

Lowering LCOE: The Next Five Years

The MHK industry needs to get its levelized cost of energy (LCOE) down to truly drive wide adoption. Wind and solar are currently below $.10 but given that tidal and river energy can provide baseload power, if MHK can provide power in the $0.15-$0.20 range, it will be a viable source of electricity.

As a representative player and leader in the MHK market, ORPC's three-year plan to drive costs down to $0.20 per kWh includes product innovation, manufacturing volume discounts, and lowering installation costs through gaining experience deploying a number of devices. Like a newly launched jet engine or automobile, the only way to help MHK companies gain wide market acceptance is to have run-time on multiple devices in multiple operating environments. Having a small fleet of devices deployed in multiple conditions would enable ORPC to refine its technology and bring it to full commercialization, as well as achieve market adoption over the next 12 to 18 months. Other industry players face similar challenges and opportunities and so the background provided about ORPC's process applies to all MHK companies.

[11] World Bank Publications, 2020 Tracking Sustainable Development Goal 7: The Energy Progress

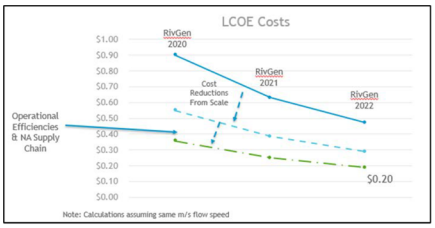


Figure 4. Estimated LCOE costs for the RivGen Power System

Product Innovation

The RivGen Power System in Igiugig, Alaska, has cycled over 7 million times over the past 10 months. This has provided ORPC's engineers with a wealth of information about individual component and overall device performance. This knowledge has been incorporated into system design, and ORPC estimates that the second unit scheduled for deployment in 2021 will see a 50 percent increase in power output. ORPC also has a series of product innovation tests over the next six months, which could contribute an additional 30-40 percent boost to output.

Volume Manufacturing

To lower LCOE, ORPC has had detailed conversations with a number of vendors about potentially managing ORPC's supply chain as it scales up. Several of these firms have refused to even quote given the small scale of our current order book. Each of the companies, however, has consistently indicated two things:

1. ORPC could reduce manufacturing costs of a device by 20-30 percent by ordering multiple units.
2. Minor adjustments to the design for manufacturing could achieve up to 50 percent cost savings between ordering a higher volume of components and minor tweaks to the device design.

ORPC asserts that if it had the ability to order ten devices, it could attract a number of U.S. vendors to bid on supplying components for its RivGen Power System. In addition, ORPC estimates that it could achieve an initial 20-30 percent cost savings from buying at volume as shown in Figure 4.

Installation Costs

The other big component of LCOE is the installation cost of the device. ORPC calculates that it can achieve meaningful economies of scale by deploying multiple devices.

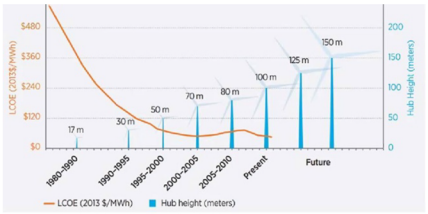
To prove the effectiveness of its technology and better understand installation and maintenance costs, it will be important to demonstrate operating performance in a variety of environments. Parameters for measurement and comparison include:

a. Single vs multiple device deployments
b. Severe winter conditions vs mild winter conditions
c. Distance to infrastructure
d. Efficiency and cost of local resources
e. Efficiency and cost of local and state permitting
f. Ease of working with regional utilities and overall receptivity

A federally-funded program that enabled MHK companies to each deploy 5-10 units would enable Congress, at a relatively low cost comparable to overall renewable energy spending programs, to finally answer questions that face the hydrokinetic industry while creating a framework for future deployments across the U.S. Predictably, the lower LCOE will parallel the decline in solar costs and the rise of annual installations (Figure 5).

Importantly, there are several communities where these policies could drive down overall electricity costs in the process. Many remote community markets in Alaska pay between $0.40 and $1.20 per kWh and so the right policies can help these communities serve as early adopter markets of this technology and help these communities achieve energy equality with their fellow Americans. In addition, many rural markets in the lower-48 also face high power costs and increasing levels of power outages due to the miles of transmission lines that need to be maintained. Helping these communities develop local microgrids will

improve their energy reliability and lower overall system costs.



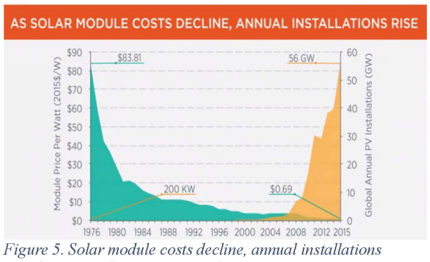


Figure 5. Solar module costs decline, annual installations rise. Source: U.S. Department of Energy

Economic Benefits

ORPC is well positioned to deploy its technology in multiple sites across the U.S. Building off the successful operation through the 2019-2020 winter in Alaska, we have identified near-term market opportunities based on our project development experience in site identification, permitting, and stakeholder engagement. These near-term opportunities are clustered around the Northeast and Alaska.

In addition, we are pursuing deployments in other regions of the U.S. including:

- Pacific Northwest
- Mississippi River
- Missouri River
- Ohio River

While this program would be an ambitious undertaking, ORPC has the internal resources and expertise coupled with an external partnership network to deliver on the necessary site assessments, permitting, and development of site-specific installation plans to accomplish this undertaking in a short period of time. Proving its capabilities to handle the rollout of a ten-unit deployment will give both foreign and domestic customers the confidence to purchase devices from OPRC. In addition, building up a track record of run-time and successful deployments will help ORPC attract additional debt and equity investors who will fund future commercial projects. This effort will move ORPC to a fully commercial business and propel MHK opportunities as conventional renewable energy solutions into the market.

Jobs

Given the significant economic impacts of the COVID-19 emergency, sustainable economic development is essential for economic recovery. Segments of the economy with projects ready to go ("shovel ready") should be prioritized for funding support. ORPC, with its technology readiness and proven approach to project development, has a portfolio of projects that meet this criterion.

ORPC will need to hire locally to successfully complete these installations. From boat captains and crew to on-site assembly and power facility operations personnel, ORPC would bring immediate employment opportunities to the communities selected. In addition, there would be on-going work opportunities for future deployment in these locations as well as annual maintenance work. Finally, there would be significant locally made purchases for supplies, goods, and services. ORPC site supervisors and senior personnel would travel to these locations and remain for several weeks, which means they would eat and lodge locally resulting in an additional boost to the local economies.

ORPC has numerous examples of this type of economic activity in Alaska and Maine, where in each state our footprint extends to dozens of partners, contractors, and services providers, and includes extensive collaboration with public universities.

Supply Chain

ORPC's plan is to activate a supply chain that utilizes a number of small businesses and

potentially a large strategic vendor to manage ORPC's supply chain. By establishing this program in today's environment, ORPC estimates that it could lead to a higher percentage of its devices being sourced domestically. This is due to the fact that in the current environment, many small and mid-size businesses that make component parts now have the capacity to take on this work, hire back workers, and diversify their businesses.

Exports

Many remote communities that rely on diesel generators for electricity and heat are situated near rivers or oceans where there is sufficient resource to deploy ORPC's devices. ORPC has established partners and a pipeline of remote community projects in Canada and Chile that present a significant near-term export opportunity for ORPC. Market interest has also been received from Africa and southeast Asia. In addition, ORPC is receiving market pull from both Canada and Europe for utility-scale RivGen installations.

ORPC estimates that this initial market adoption alone represents a multi-billion-dollar market for its devices. Accelerating ORPC's speed to full commercialization and adding to its run-time track record will increase demand in the global market and give ORPC the ability to establish itself ahead of its growing list of European- and Chinese-based competitors.

Enabling Regulatory Policy

The permitting and licensing for MHK projects in state waters is a lengthy and costly process involving numerous consultations with stakeholders and the approval of local, state, and federal agencies.[12] The Federal Energy Regulatory Commission (FERC) has licensing jurisdiction over hydrokinetic projects in state waters.

The licensing process for commercial hydroelectric dams is well established and is used as a framework to authorize the testing and demonstration of MHK devices. FERC developed an innovative approach to licensing smaller-scale MHK devices and in 2008, and issued a whitepaper, *Licensing Hydroelectric Pilot License Projects*. This whitepaper established a pilot project licensing process, based on the integrated licensing process established for commercial hydroelectric development, that provides an opportunity for developers to prove emerging hydrokinetic technology devices, determine appropriate sites, and gather information on environmental and other effects of the devices.

The process for obtaining an MHK pilot license involves four main steps:

- Site assessment/informal consultation
- Preliminary permitting
- Pre-filing activity
- Post-filing Activity

For pilot projects, FERC's *Guidance for Pilot Project Licensing* indicates that a license decision may be reached within 6-12 months from the filing of a complete application. This 6-12-month timeframe does not include other required authorizations, so the overall time it takes to authorize an MHK pilot project exceeds 12 months—with initial industry estimates of 5 years when local, state, and federal permits are considered.

A review of MHK pilot projects in state waters licensed by FERC shows that the average time to obtain approval is 7.5 years. This time frame is prohibitive to scaling-up the commercialization of mature MHK devices in state waters.

ORPC recommends the following adjustments to provide a more efficient permitting pathway for a large-scale commercialized permitting pathway:

- FERC to revisit the 2008 *Licensing Hydroelectric Pilot License Projects* whitepaper and revise guidance to better reflect the realities scale and impact of MHK devices to the environment

[12] U.S. Department of Energy, Handbook of Marine Hydrokinetic Regulatory Processes, August 2020

- FERC to revise memorandums of understanding (MOUs) with state and federal agencies for more streamlined and timely coordination between agencies in the licensing process, like the one that the State of Maine and FERC executed
- Congress to provide an exemption for MHK projects similar to that provided for qualifying conduit hydropower facilities, creating an accelerated licensing framework with FERC

Call-to-Action

The Department of Energy Office of Energy Efficiency & Renewable Energy's Water Power Technologies Office (WPTO) provides tens of millions of dollars of funding annually on a competitive basis to industry, university research centers, and national laboratories supporting hydrokinetic technology development at various technology readiness levels. Between 2010 and 2020, budget levels rose from approximately $30 million to about $100 million annually.[13]

Related support is also provided from DOE's Office of Science Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, the Advanced Research Projects Agency – Energy (ARPA-E), and the Office of Indian Energy Policy and Programs. The U.S. Department of Agriculture also supports remote community power system development.

ORPC has been awarded funding from programs offered by all of these federal offices. ORPC also provides its own funding resources to complement the public investments, and in fact the awarding of federal funds to our company has always spurred additional private equity investments in our company. We are grateful to DOE for their financial, program, and project management support of our efforts, and we support the American Energy Innovation Act developed by the Senate Committee on Energy and Natural Resources, which urges continuance and expansion of DOE's role our industry. Nonetheless, as the MHK industry advances to commercialization and provides necessary energy solutions to domestic markets, other public sector financial instruments will be required to help the industry fully mature. As a comparison, consider the extraordinary progress achieved by the wind and solar industries. In the past decade, these industries received about $75 billion in various levels of support to enable technology readiness, rapid cost reduction, and workforce talent development. This allowed the wind and solar industries to become mainstream market options in the U.S., but somehow the country lost the manufacturing advantage in these industries to Europe and China. A similar scenario may play out in the MHK sector.

The European Union recognizes this opportunity and are looking to spend roughly €670 million over the next 5 years alone in support of ocean energy. They expect the ocean energy industry to provide 10 percent of Europe's power needs by 2050 and create over 400,000 direct jobs in a global industry that they expect to reach €53 billion in annual revenues, which is about the size of the U.S. market for pickup trucks.[14]

As a first step, we propose an infrastructure funding program through DOE to support communities that want to install river and tidal power systems. Most early adopter communities have unsustainably high costs of power and do not have the economic resources to purchase systems. An infrastructure funding program will not only grow renewable energy but also improve economic opportunity for these communities through lower energy costs.

Second, DOE has a financial program that can assist with domestic MHK industry goal of increasing the number of devices in the water and by extension our country's interest in long-term job creation. The Title XVII Innovative Energy Loan Guarantee Program, a $25 billion investment tool, is a good example. MHK technologies are a perfect fit for the program's

[13] https://www.energy.gov/eere/water/water-power-technologies-office-budget

[14] https://www.oceanenergy-europe.eu/ocean-energy/

eligibility requirements—new technology, reduce greenhouse gases, located in U.S., etc. But the minimum requirement of $1 million upfront costs for due diligence is unreasonable as it effectively makes the program unavailable to projects below the $40 million to $50 million range. We propose that Congress simply carve out approximately 2 percent of the program to create a $500 million subset for smaller projects. This loan program can be a game changer by allowing MHK companies and their customers to structure loan, loan guarantee and leasing company structures that can advance the industry and help meet the nation's renewable energy, job creation, and energy security goals.

With the proposed funding programs and accelerated permitting assistance, the U.S. is poised to achieve a 100 percent clean energy economy and net-zero emissions, along with its attendant sustainable economic development through job creation.

The CHAIRMAN. Mr. Davies, thank you. We appreciate you sharing some of the innovation that we are seeing up in Alaska.

Let's now go to Ms. Siri Kindem. Welcome to the Committee.

STATEMENT OF SIRI ESPEDAL KINDEM, PRESIDENT, EQUINOR WIND U.S.

Ms. KINDEM. Chairwoman Murkowski, Ranking Member Manchin and members of the Committee, I appreciate the opportunity to be here today and to discuss with you offshore energy technologies, especially offshore wind. My name is Siri Espedal Kindem, and I'm the President of Equinor Wind U.S. and I'm very pleased to join you today and take you through the exciting developments of the offshore wind industry.

Equinor is a global energy company with over four decades of experience in developing, owning and operating large-scale offshore energy projects. The resource experience and technical capability that Equinor has acquired over time has allowed us to become a global leader in the development and operations of offshore renewable resources. Equinor currently owns, operates and markets the output of numerous operating offshore wind facilities, including the first floating offshore wind farm, Hywind Scotland. We truly believe that floating wind, which will be because of deeper water in the U.S. in the future, is the next big breakthrough in renewables. With floating wind turbines already in production, Equinor is the world's leading floating offshore wind developer.

Next step first is that we are currently developing Hywind Tampen in the North Sea. This will be the world's first floating wind farm built to power existing offshore oil and gas platforms. When Hywind Tampen is completed, it will be the world's largest floating offshore wind farm. So this will be a test case for further development of floating wind around the world and will explore the use of new and emerging technology and insulation methods that represent an essential step in industrializing solutions and representing costs for the future projects.

So then shifting to the U.S. business, Equinor Wind is developing two bottom-fixed offshore wind projects on the East Coast of the United States: Beacon Wind off the New England coast and Empire Wind in the waters offshore. The Empire project has incurred one offtake agreement for 816 megawatts which is the total of about 40 percent of our lease area. So we plan to participate in the future bids for solicitations to provide the power for the remainder of the Empire lease and the Beacon lease which as a total have then a combined capacity of approximately 4 gigawatts. But it is important to note these big projects, they have big timeframes. Commercial operations for Empire is expected in the mid-2020s and in the late mid-2020s for Beacon.

Since 2016, Equinor Wind has, in the planning and development of its U.S. offshore wind project, been engaging with key stakeholders including many dialogues and meetings with fisheries. We believe that mitigation measures to reduce impact of fisheries should be identified and developed in close consultation with relevant fisheries' stakeholders and then early in the project development process. So we endeavor to minimize disruptions to fisheries at all stages of project life. Consultations have already heeded valu-

able insight that have been incorporated into the Equinor Wind survey and planning processes.

So thank you again for inviting me to participate. We appreciate that the Committee's interest in offshore wind development in the U.S., and we're looking forward to working with you and also look forward to answering your questions. Thank you.

[The prepared statement of Ms. Kindem follows:]

Testimony of Siri Kindem, President, Equinor Wind U.S.
Before the
U.S. Senate Committee on Energy and Natural Resources
September 22, 2020

Chairman Murkowski, Ranking Member Manchin and members of the Committee, I appreciate the opportunity to discuss with you emerging offshore energy technologies, and more specifically offshore wind. My name is Siri Espedal Kindem and I am the President of Equinor Wind US. My responsibilities include our offshore wind portfolio throughout the U.S. East Coast, including Empire Wind, an 816 MW project off the coast of Long Island. I have had various roles at Equinor, most recently as head of Operations North in the Norwegian and Barents Sea and previously I was head of renewables for Equinor's New Energy Solutions (NES), having led operations, investment strategy, technology, and development for numerous projects. I am very enthusiastic to be here today to take you through some of the developments in this exciting and burgeoning industry.

Background

Equinor Wind US LLC (Equinor Wind) is a subsidiary of Equinor ASA (Equinor), a global energy company with over four decades of experience developing, owning, and operating large-scale offshore energy projects. As a broad energy company, Equinor has 21,000 committed colleagues developing oil, gas, wind and solar energy in more than 30 countries worldwide. The resources, experience, and technical capabilities that Equinor has acquired have allowed us to become a global leader in the development and operation of offshore renewable resources and to build a growing renewable portfolio. Equinor currently owns, operates, and markets the output of numerous offshore wind facilities in operation, including the world's first floating offshore wind farm, Hywind Scotland. Equinor Wind is actively developing offshore wind projects on the east coast of the U.S., namely Beacon Wind in lease area OCS-A 0520, in the waters offshore New England, and Empire Wind in lease area OCS-A 0512 in the waters offshore New York. We are also pursuing opportunities on the west coast.

Equinor's Transition to a Broad Energy Company

In 2015, we launched a new vision for the company. We determined that business as usual was not an option. We had to change in order to be competitive at all times, reduce costs and work simpler and smarter. We also set out to help transform the oil and gas industry, and transition to a low carbon future, both through producing oil and gas with as low emissions as possible and by maximizing opportunities in renewable and low carbon solutions. It was on this basis that Equinor's New Energy Solutions business area was established and Equinor became "an energy company" rather than an oil and gas company. As stated recently by Equinor's CEO, Eldar Sætre, "Equinor's strategic direction is clear. We are developing as a broad energy company, leveraging the strong synergies between oil, gas, [and] renewables . . . . "[1]

New Energy Solutions was tasked with developing a profitable renewables business and new lower-carbon opportunities for Equinor's core products – oil and gas. The competence we have gained through more than 40 years as an oil and gas company forms the backbone of our efforts in offshore wind. By 2026 Equinor expects to increase our installed capacity from renewable projects to between 4 and 6 GW, based mainly on our current project portfolio. This is approximately 10 times higher than today's capacity, implying an annual

[1] Equinor's Climate Roadmap, https://www.equinor.com/en/how-and-why/climate.html, 2020.

average growth rate of more than 30% in electricity production. Towards 2035, we anticipate increasing installed renewables capacity further to between 12 and 16 GW, depending on availability of attractive project opportunities. Equinor's New Energy Solutions unit also plans annual gross capital expenditure of between $500 million and $1 billion in 2020-21 and between $2 billion and $3 billion in 2022-23. The past few years have been transformational for Equinor's offshore wind portfolio and we are on the path to becoming a global offshore wind major.

Empire Wind

Empire Wind Phase 1 is planned for the western half of our New York Bight lease area of approximately 80,000 acres, in federal waters an average of 20 miles south of Long Island and between 72 and 138 feet deep. The project is expected to be developed with 60-80 wind turbines, with an installed capacity of more than 10 MW each. Total investments will be approximately $3 billion. In July 2019, Empire Wind was awarded a long-term contract for renewable energy certificates for 816 MW in New York State's first competitive large-scale offshore wind solicitation. The project will be a major contributor to meeting the state's ambitious clean energy and climate goals and will power over 500,000 New York homes. We plan to participate in additional state processes in New York and New Jersey to compete to provide power from the remainder of the Empire lease as Empire Wind Phase 2. Commercial operation is expected to begin in the mid-2020s. We have submitted to BOEM our Construction and Operations Plan and are working on a supplement for submittal this month.

Beacon Wind

In early 2019, Equinor successfully secured Lease OCS-A 0520 offshore New England for $135 million. The project, called Beacon Wind, covers 128,000 acres and is located approximately 60 miles east of Montauk Point and 20 miles south of Nantucket. The lease has the potential to be developed with a total capacity of more than 2.4 GW.

We initiated state-of-the-art aerial wildlife surveys in December 2019, and we will take steps to secure all necessary permits for the project over the next 5-7 years. We will also undertake geophysical and geotechnical surveys to gain information about seabed features, geological conditions, presence of hazards, and other features of the lease area. When complete, Beacon Wind will provide renewable power to more than a million households in the Northeast. We anticipate submitting permit applications in 2022 and depending on the review timeline beginning construction in the mid-2020s and commencing operation in the second half of the 2020s.

Stakeholder Engagement

Since 2016, Equinor Wind has been engaged intensively with key stakeholders, including fisheries, in the planning and development of its U.S. offshore wind projects. In 2017, we began meeting with commercial fishermen and their representatives, universities, and research organizations on the East Coast. Fisheries outreach intensified in January 2018 with the selection of a Fisheries Liaison Officer (FLO). Since then, we have documented more than 1,000 fisheries contacts with commercial and recreational fishermen including meetings on docks, company offices and more formal settings, fisheries trade shows, telephone calls, emails, presentations, social media, the Equinor website, and others. Equinor Wind added a Fisheries Manager in 2019. Between them, the FLO and Fisheries Manager have over sixty years' experience working with

commercial and recreational fisheries. Fisheries Communications Plans and Fisheries Mitigation Plans have been developed and discussed at length with fishermen and agencies and published on the Equinor website.

Equinor Wind strongly believes that mitigation measures to reduce impacts on fisheries should be identified and developed in close consultation with relevant fisheries stakeholders early in the project development process. This is accomplished through an iterative process of project design, including spatial planning, cable routing, timing of works, wind farm layouts, and consideration of construction and operations methods. The Empire Wind and Beacon Wind Project Teams have been following these principles rigorously since Equinor Wind secured a Lease Area in 2017. Equinor Wind endeavours to minimize disruption to fisheries at all stages of project life, including during survey activity, construction, operations, maintenance, and decommissioning. Consultations have already yielded valuable insights that have been incorporated into our survey and planning processes. We have taken various actions and played multiple roles to minimize potential impacts on fisheries, including the following:

- Modifying survey schedules to avoid areas with active seasonal fishing (over 300 survey days with no fishing gear interaction);
- Early spatial planning and real-time adaptive management to avoid high use, high value, and high sensitivity fisheries areas in planning the export cable routes;
- Holding extended consultations (in progress) with fisheries, including the Responsible Offshore Development Alliance (RODA), regarding the Empire Wind layout,
- In cooperation with other developers, agreeing to lay out Beacon Wind on a 1 x 1 nautical mile grid;
- Founding member of the RODA Joint Industry Task Force;
- Board member of the Responsible Offshore Science Alliance (ROSA);
- Member of the New England Fishery Management Council Habitat Advisory Panel;
- Establishing a fisheries communications and outreach strategy to effectively engage with and solicit input from a wide range of fishers and stakeholders in multiple regions; and
- Applying feedback in early spatial planning and setting “Layout Rules” for the thoughtful development of project areas.

Floating Offshore Wind

With tried and tested floating wind turbines already in production, Equinor is the world’s leading floating offshore wind developer. We expect floating wind to be the next big breakthrough in renewables due to the numerous benefits it provides. For example, up to 80 % of the world’s offshore wind potential is in water depths that are not suited for bottom-fixed foundations. Moreover, floating wind farms can capture winds that are stronger and more consistent further out to sea. In addition, removing water depth constraints allows us to select the best sites in the world, thereby taking advantage of higher capacity factors because of the better wind conditions farther offshore. Finally, floating turbines can be placed almost anywhere the water is deeper than about 200 feet, thereby opening a world of new markets and opportunities.

We believe that our offshore experience from the North Sea and around the world makes us uniquely qualified to lead the way and further develop floating offshore wind. Indeed, most floating offshore wind designs originated in the oil and gas industry. Equinor’s Hywind technology, for example, is based on a spar buoy design with stability provided by gravity. In addition, our proprietary floating wind turbine motion controller uses sensors and computers to regulate the turbine blades in relation to the wind gusts, dampening tower

movements, reducing strain on the moorings and maximizing electricity production. As a technology-agnostic developer, however, we will select the substructures and designs for our floating wind installations best suited to the local conditions where they will be used. Our experience with the Hywind demo floating wind turbine offshore Norway and our Hywind Scotland wind farm has given us valuable experience to build on.

Currently, we are developing Hywind Tampen, the first floating wind farm in the North Sea and the world's first floating wind farm to power offshore oil and gas platforms. Hywind Tampen will also be the world's largest floating wind farm and it will be a test case for further development of floating wind, exploring the use of new and larger turbines, installation methods, simplified moorings, concrete substructures and integration between gas and wind power generation systems. The project will consist of 11 wind turbines based on Equinor's Hywind floating offshore wind technology and will have a combined capacity of 88 MW. The project is estimated to meet about 35% of the annual power demand of the Snorre A and B, and Gullfaks A, B and C platforms in the Norwegian North Sea. In periods of higher wind speed this percentage will be significantly higher. Hywind Tampen will help reduce the use of gas turbine power, while also offsetting 200,000 tons of CO2 emissions and 1000 tons of NOx emissions per year. Together with our partners in the Snorre and Gullfaks fields, we reached a final investment decision (FID) in October 2019 and awarded key contracts for project in the same month.

Floating wind technology is in an early phase compared with bottom fixed. Relatively few megawatts have been installed worldwide, and the supply chain is immature. This makes the current cost of floating offshore wind higher than bottom fixed. This is about to change, and we expect gigawatt projects in Asia and Europe within the next 5-10 years. We are seeing a cost reduction of 40% from Hywind Scotland to Hywind Tampen, and we believe floating wind will compete with bottom fixed prices/cost by the end of this decade.

Partnership with BP

On September 10, 2020 Equinor announced an agreement with BP to sell 50% non-operated interests in the Empire Wind and Beacon Wind assets for a total consideration before adjustments of $1.1 billion. Currently, Equinor holds a 100% interest in the Empire Wind lease, and the Beacon Wind lease. The transaction is in line with Equinor's renewable strategy to access attractive acreage early and at scale, mature projects, and capture value by de-risking high equity ownership positions.

Equinor will remain the operator of the projects in these leases through the development, construction and operations phases and it is anticipated that the wind farms will be equally staffed, during the operations phase. The partnership underlines both companies' strong commitment to accelerate the energy transition and demonstrates Equinor's ability to create value from developing offshore wind projects. Combining our strengths will enable us to grow a profitable offshore wind business together in the U.S.

Through this partnership Equinor and BP will consider future joint opportunities in the U.S. for both bottom-fixed and floating offshore wind and will leverage relevant expertise to jointly grow scale. As the partnership develops, both companies hope to expand this cooperation further in a market that is forecast to grow to between 600 and 800 GW globally by 2050.

BP's acquisition of the interests in Empire Wind and Beacon Wind has an effective date of 1 January 2020 and is expected to close in early 2021, subject to customary conditions including purchase price adjustments and authority approval.

Permitting in the United States

Equinor Wind is closely following BOEM's review of the Vineyard Wind project, and we commend the agency for its efforts in the Draft Supplemental Environmental Impact Statement (DSEIS) to fulfill its obligations under the National Environmental Policy Act (NEPA) and to advance its statutory mandate under the Outer Continental Shelf Lands Act to develop the nation's offshore renewable resources subject to appropriate environmental safeguards.

Equinor submitted comments to BOEM on the DSEIS and we would like to highlight for the Committee a few of the issues that we addressed.

Turbine Spacing

BOEM presented many alternatives for turbine spacing in the DSEIS. We have agreed to a uniform 1 x 1 nautical mile spacing between wind turbines in the New England wind energy areas in order to enhance safety and navigation, reflected in alternative D.2. This option best balances the needs of developers, other offshore users, and navigation safety. Alternative D.2 involves arranging the wind turbines with a minimum spacing of one nautical mile between all turbines in the east-west orientation so that vessels have an unobstructed path between rows of turbines. As the DSEIS explained, this alternative should reduce conflicts with existing ocean uses, such as commercial fishing, by facilitating the established methods of mobile and fixed gear fishing practices and vessels fishing in an east-west direction. This uniform layout was presented to the Coast Guard for its consideration in November 2019, and the uniform spacing concept was reviewed in the Massachusetts Rhode Island Port Access Route Study (MARIPARS). Coast Guard's final MARIPARS report, issued on May 27, 2020, clearly supports the selection of Alternative D.2. In our comments, we urged BOEM to closely consider Coast Guard's expertise and advice, as reflected in the MARIPARS report.

In addition, we urged that the 1 x 1 nautical mile spacing agreement not be used to pre-ordain turbine spacing requirements for other offshore wind projects. These projects will be subject to individual and specific review by BOEM, with Coast Guard's input as a cooperating agency.

Economic Impact

The starting point for BOEM's cumulative effects analysis in the DSEIS broadly included all development that would meet the renewable energy goals of the states, within the available wind resource. These states, in turn, require or expect significant economic development within the state as part of awarding offtake agreements. For instance, Equinor has committed $792 million in economic benefits to New York. The efforts to develop offshore wind projects will result in significant economic development in many forms, such as increased tax revenues and thousands of jobs, as well as intangible benefits such as increased energy security. The DSEIS mentions little of the considerable contributions offshore wind development is expected to make. For instance, the DSEIS does not address the significant direct and indirect jobs offshore wind development is expected to generate, nor does it appear to account for the domestic supply chain that will be developed to support the burgeoning industry.

Congress should join industry in urging that BOEM give greater consideration and weight to the beneficial impacts from offshore wind development off the Atlantic Coast and should appropriately compare the full scope of the expected economic benefits, not just those from New England, to the potentially adverse impacts.

Looking Forward

Several policy considerations should be considered by the Department of the Interior, the Department of Energy, and Congress to help ensure a thriving offshore wind industry.

- We urge the Department of the Interior to issue Notices of Intent to prepare Environmental Impact Statements (NOIs) for leased offshore wind projects. There are many projects in the queue awaiting BOEM's issuance to begin the environmental review and public comment period. By moving forward with NOIs, certainty will be provided not only to the developers, but the market will see forward progress leading to investments in the supply chain as well.

- Unlike the mature offshore oil and gas leasing program, there currently is no schedule for offshore wind auctions. Now that the offshore wind program is more mature, development has gained momentum and attracted significant capital. To continue the orderly and expeditious development of OCS wind resources, developers and other participants in the offshore wind sector need more certainty around future leasing. Consequently, we urge BOEM, working in consultation with state partners, to develop an offshore wind leasing schedule. Doing so will provide better information for planning and prioritizing investments, and it would be another step in demonstrating the Department's commitment to offshore wind.

- With respect to the Investment Tax Credit (ITC), Congress should provide an option to satisfy the continuity requirement by meeting "continuous efforts" and extend the Continuity Safe Harbor deadline for the "start of construction" to seven years. Making these changes will allow taxpayers to demonstrate that a business may show either continuous efforts or continuous construction, regardless of how construction started, for purposes of meeting the continuity requirement. Additionally, it will allow continuous efforts for projects in any start year regardless of whether a project started under the physical work test or the five percent test. This will ease the administrative burden for both IRS and taxpayers if continuous efforts, rather than continuous construction, is applied. Along with these efforts, Equinor supports an extension of the ITC for offshore wind projects beyond the end of 2020 expiration.

- Congress should increase funding to BOEM, in line with the President's budget, for permitting review to provide reliable schedules, which will alleviate uncertainty for the offshore industry about the feasibility of getting through the relevant permitting processes. Additional funding will allow BOEM to ensure timely permitting, reliable access, and a predictable regulatory environment throughout the American energy sector. This certainty will provide schedules, which are critical to attracting investment, securing supply chain commitments, and addressing workforce development needs in the offshore industry.

- We encourage Congress to provide robust funding for the Office of Energy Efficiency and Renewable Energy and the Wind Energy Technologies Office at the Department of Energy (DOE). As members of the National Offshore Wind Research & Development Consortium, and frequent partners with the DOE National Labs, Equinor supports funding for needed research and development efforts by DOE.

Conclusion

We appreciate the Committee's interest in offshore wind development in the U.S. and we are looking forward to working with you to move this burgeoning industry forward.

I look forward to answering your questions.

The CHAIRMAN. Thank you, Ms. Kindem, we appreciate that.

Our final member on the panel this morning is Mr. Jonathan Lewis with the Clean Air Task Force. Welcome.

STATEMENT OF JONATHAN F. LEWIS, SENIOR COUNSEL, CLEAN AIR TASK FORCE

Mr. LEWIS. Thank you. My name is Jonathan Lewis. I'm Senior Counsel for the Clean Air Task Force, a non-profit organization that advocates for the change in technologies and policies needed to get to a zero-emissions, high-energy planet at an affordable cost. I want to thank Chairman Murkowski, Ranking Member Manchin and the rest of the Committee for hosting me today.

To avoid the worst impacts of climate change, we need to eliminate greenhouse gas emissions from nearly every sector of the major—of the global economy by 2050. Marine shipping is one of those sectors. If it were a country, marine shipping would rank sixth on a list of countries with the highest greenhouse gas emissions, behind Japan, but ahead of Germany, the United Kingdom and South Korea. Alone, any greenhouse gas emissions from the marine sector requires a wholesale shift away from carbon-intensive fuels and points to the urgent need to develop and deploy alternative fuels to offer the benefits of oil and gas but without the carbon. Hydrogen is one such fuel. Ammonia which is made by combining hydrogen with nitrogen, is another. Neither fuel contains carbon atoms so they emit zero CO_2 when they are converted to energy. Although the vast majority of hydrogen and ammonia is currently produced in carbon intensive ways, both hydrogen and ammonia can be produced through processes that emit little or no greenhouse gas.

One option for producing zero carbon fuels is to install a carbon capture and sequestration system at methane reformers that use natural gas to make hydrogen. If effective emission controls are put in place, they significantly reduce methane leakage throughout the natural gas production transformed distribution system and if all or nearly all of the CO_2 produced by the reformer is captured and sequestered, making hydrogen and ammonia at gas reforming facilities would emit low to zero carbon. A second option is electrolysis in which electricity is used to split water into hydrogen and oxygen. If a zero-carbon power source is used to generate electricity, such as solar, wind or nuclear, electrolytic production of hydrogen results in zero carbon emissions.

Both of these production processes are massively scalable, in part because the ingredients for making hydrogen and ammonia are readily obtainable and nearly inexhaustible. Ammonia is a particularly compelling candidate for fuel shifting for marine shipping for reasons outlined in recent studies by University College London, Siemens Gamesa, Shell and others. Ammonia is relatively easy to store and transport, and it appears to be compatible with retrofitted and purpose-built internal combustion engines which might limit the extent to which existing energy systems need to be wholly replaced. Ports already site and build ammonia storage and handling equipment, thereby avoiding a large challenge associated with the transition to alternate fuels and marine vessels are al-

ready fueled by professionals that could be trained to safely manage ammonia.

There are important steps that Congress and this Committee can take to support the development and scale-up of a zero carbon fuels industry and the decarbonization of marine shipping. First, we recommend that the Senate immediately pass the American Energy Innovation Act of 2020. Second, the Committee should help reduce technology costs by directing DOE to sponsor research, development and deployment of ammonia reciprocating engines, high temperature electrolysis and other critical technologies. Third, the Committee should direct federal support to zero carbon fuel production and end-use technology adoption through production and investment tax credits, through rebates and incentives for zero carbon fuel end use technologies and through tax credits for pipelines, terminals, storage tanks and other infrastructure for zero carbon fuels. Finally, Congress should kick-start zero carbon fuels and marine shipping decarbonization through development loans and cost share grants that facilitate the development of key zero carbon fuel production transport and end-use hubs across the United States.

The shift to zero carbon refuels will take place within the context of a much broader and larger decarbonization effort, replacing half of the more than 250 quadrillion BTU of fossil fuels we currently use directly for transportation, industry and heating would require on the order of a billion metric tons of clean hydrogen per year. This is the gigaton clean hydrogen challenge for mid-century. Meeting that challenge or even more modest hydrogen utilization scenarios will require that nuclear or renewable electricity production increase by at least an order of magnitude or that billions of tons of CO_2 are captured for methane reforming and sequestered each year or both. This is on top of the scale required to provide clean electricity for easier to electrify sectors of the economy. These scenarios all represent extremely large markets and opportunities for innovation.

The Clean Air Task Force is eager to work with this Committee on steps that can be taken to seize that opportunity. Thank you for your time.

[The prepared statement of Mr. Lewis follows:]

Written Testimony of

Jonathan F. Lewis
Senior Counsel
Clean Air Task Force

Before the U.S. Senate Committee on Energy & Natural Resources

"Hearing on Offshore Energy Technologies"

September 22, 2020

My name is Jonathan Lewis. I am Senior Counsel at the Clean Air Task Force, a nonprofit organization that advocates for the change in technologies and policies needed to get to a zero-emissions, high-energy planet at an affordable cost, so that we can meet the world's rising energy demand in a way that is financially, socially and environmentally sustainable.[1] I work on Clean Air Task Force's effort to promote the development and deployment of zero carbon fuels.

I want to thank Chairman Murkowski, Ranking Member Manchin, and the rest of the Energy and Natural Resources Committee for inviting me to testify today, and for holding this hearing on the important topic of emerging offshore energy technologies.

[1] Mitigating climate change requires full decarbonization of major economic sectors

Earth's average surface temperature has increased by about 1°C since 1880.[2] Research strongly indicates that limiting planetary warming to 1.5-2.0°C above preindustrial levels is necessary to avoid the worst impacts of climate change.[3] To stay within the carbon budget implied by the 2°C target, much less a 1.5°C target, annual greenhouse gas emissions must peak soon and then decline rapidly.[4]

To achieve that goal, we need to eliminate greenhouse gas emissions from nearly every major sector of the global economy by 2050. Sectors that cannot fully eliminate their greenhouse gas emissions must reduce those emissions to the fullest extent possible.[5]

The marine shipping sector is one of those sectors. If it were a country, marine shipping would rank sixth on a list of countries with the highest greenhouse gas emissions, behind Japan but ahead of Germany, the United Kingdom, and South Korea.[6] According to the International Maritime Organization (IMO), the sector's greenhouse gas emissions "could grow between 50% and 250% by 2050;"[7] University Maritime Advisory Services (UMAS), a

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1 www.catf.us

2 Rebecca Lindsey and LuAnn Dahlman, National Oceanic and Atmospheric Administration, *Climate Change: Global Temperature* (2020) (https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature).

3 Intergovernmental Panel on Climate Change, *Global Warming of 1.5°C, an IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (2018) (https://www.ipcc.ch/sr15/).

4 *Id.*

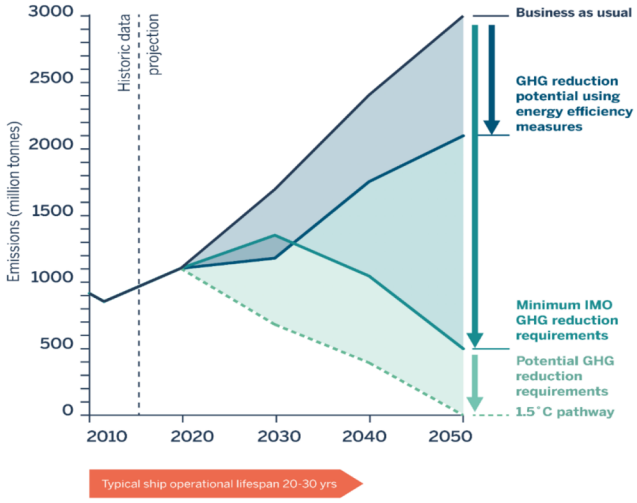
5 See, e.g., David G. Victor, Frank W. Geels, Simon Sharpe, *Accelerating the Low Carbon Transition* (2019) (https://www.brookings.edu/wp-content/uploads/2019/12/Coordinatedactionreport.pdf).

6 International Maritime Organization, *Reduction of GHG Emissions from Ships: Fourth IMO GHG Study, MEPC 75/7/15* (2020) (the global shipping sector emitted 1.076 billion tonnes of greenhouse gas in 2018 (a 9.6% increase since 2012), of which 1.056 billion tonnes were carbon dioxide; the sector's emissions account for 2.89% of global anthropogenic GHG emissions in 2018) (https://docs.imo.org/Shared/Download.aspx?did=125134); Union of Concerned Scientists, *Each Country's Share of CO2 Emissions* (2020) (the shipping sector's CO2 emissions in 2018 (1.06 billion tonnes) are lower than the 2018 CO2 emissions from Japan (1.16 billion tonnes) but higher than those from Germany (0.75 billion tonnes)) (https://www.ucsusa.org/resources/each-countrys-share-co2-emissions).

7 International Maritime Organization, *Greenhouse Gas Emissions* (2020) (http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/GHG-Emissions.aspx).

marine sector consultancy affiliated with University College London, projects that the sector's emissions will grow 200% by midcentury under a business-as-usual scenario.[8]

Fig. 1. Actual and Projected Emission Trajectories for Marine Shipping, 2010-2050 (UMAS)



Given typical ship operational lifespans and midcentury net-zero carbon targets, investments in zero-carbon fuel infrastructure that can be applied in current ship designs need to be a policy priority.

Marine shipping is one of several segments of the global economy frequently referred to in climate change mitigation discussions as a "hard to abate" sector—a designation typically applied to sectors that cannot be readily electrified and therefore decarbonized through carbon-free electricity. Eliminating greenhouse gas emissions from the marine shipping sector will indeed be difficult, but it can be done. Moreover, it can be done over the next few decades, through the deployment of known technologies. By supporting the commercialization of those technologies, the United States, Congress, and this Committee can play a leading role in helping the marine sector decarbonize.

Zero carbon fuels and the engines, turbines, boilers, and fuel cells that can run on zero carbon fuels are at the center of this effort.

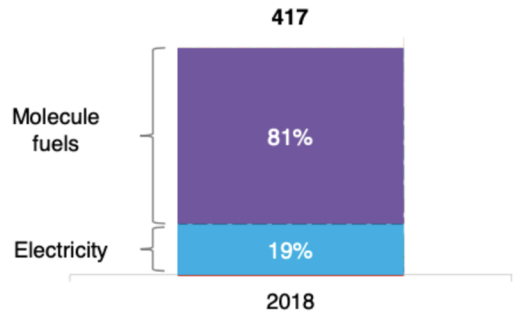
8 UMAS, *How Can Shipping Decarbonise?* (2019) (https://www.u-mas.co.uk/Latest/Post/411/How-can-shipping-decarbonise-A-new-infographic-highlights-what-it-d-take-to-decarbonise-shipping-by-2050).

[2] What are zero-carbon fuels?

Zero carbon fuels are fuels which emit no carbon dioxide when consumed, and for which lifecycle greenhouse gas emissions are minimized. In practice this is likely to mean hydrogen (H_2) and ammonia (NH_3)—which can be converted to energy in compatible fuel cells, reciprocating engines, turbines, and other machines—when the hydrogen or ammonia is the result of certain production pathways. The concept of minimal lifecycle greenhouse gas emissions is likely to evolve over time but in any event means a significant reduction when compared to the fossil fuels being displaced. There are other fuels that offer potentially significant reductions in lifecycle greenhouse emissions, such as synfuels made from hydrogen and carbon removed from air, however these may present different infrastructure challenges and reflect different issues related to scale up and economics.

The world currently uses carbon-containing fossil fuels (oil, gas, coal) to power approximately 90% of transportation,[9] 65% of electricity generation,[10] and 76% of industrial energy consumption.[11] Liquid and gaseous fuels are especially convenient, and account for the bulk of US and global energy end-use (see Fig. 2).

Fig. 2. Global Final Energy Consumption in 2018 (EJ)



Much of our carbon emissions come from use of fossil fuels. Replacement of those high-carbon emitting fuels with zero-carbon emitting alternatives is an essential pathway to deep decarbonization. (Data: IEA via BNEF12)

The International Energy Agency (IEA), US Energy Information Administration (EIA), and other analysts project that oil will continue to power a significant portion of the transportation sector for decades, even when high rates of future electrification are

9 BP, *Energy Outlook: Transport* (2018) (https://www.bp.com/en/global/corporate/energy-economics/energy-outlook/demand-by-sector/transport.htm).

10 BP, *Statistical Review of World Energy*, at 48 (2018) (https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review/bp-stats-review-2018-electricity.pdf).

11 US Energy Information Administration, *International Energy Outlook 2019*—Table: Delivered energy consumption by end-use sector and fuel (https://www.eia.gov/outlooks/aeo/data/browser/#/?id=15-IEO2019&region=4-0&cases=Reference&f=A).

12 Koban Bhavnagri, BNEF, *Hydrogen Economy Outlook* (2020) (presentation on file with CATF).

assumed. Even if *all* light duty vehicles are electrified by 2040, demand from the rest of the transportation sector (comprised of harder-to-electrify vehicles like trucks, trains, ships and aircraft) would still exceed 35 million barrels of oil per day, per IEA data.[13]

Safeguarding against the worst impacts of climate change will likely require a near-total reduction in carbon emissions from the transportation, power, and industrial sectors. Doing so requires a wholesale shift away from carbon-intensive fuels, and points to the urgent need to develop and deploy alternative fuels that offer the benefits of oil, gas, and coal—but without the carbon. Two of the most promising options are hydrogen and ammonia.

The global marine shipping sector consumed 222 Mtoe of residual oil, marine diesel oil, and LNG in 2019 (containing approximately 9 quadrillion btu of energy).[14] Shifting that consumption in its entirety to zero carbon fuels—which are currently not used at all to power marine shipping—will require significant effort from both the private and public sectors. According to an analysis by the Global Marine Forum (GMF), fully decarbonizing the shipping sector by 2050 through a transition to hydrogen and ammonia fuels will cost between USD $1.4-1.9 trillion.[15] The bulk of these investments (87%) would be for fuel production; GMF estimates that only 12% of the investment would go toward to propulsion systems and fuel storage and another 1% would go to energy efficiency upgrades.[16]

The shift to zero carbon marine fuels will take place within the context of other decarbonization initiatives throughout the broader economy—and other demands for hydrogen and ammonia. As discussed in Part 4, below, hydrogen and ammonia fuel could play important roles in the elimination of greenhouse gas emissions from several economic sectors, including other types of heavy-duty freight transport, industrial processes, commercial and residential space heating, and power (by providing long-duration storage).

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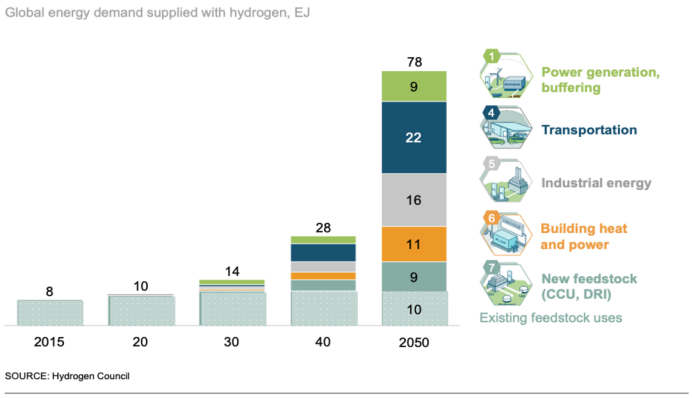
13 International Energy Agency, *World Energy Outlook 2016*—Table 3.3: World oil demand by sector in the New Policies Scenario (2016).

14 International Energy Agency, *International Shipping* (2020) (https://www.iea.org/reports/international-shipping).

15 Global Maritime Forum, *Getting to Zero Coalition Insight Series: The scale of investment needed to decarbonize international shipping* (2020) (the level of investment depends on the production method(s) used to make the hydrogen and the ammonia, with an approach that depends fully on SMR+CCS representing the low-end cost estimate and an approach that depends fully on pure electrolysis production representing the high-end) (https://www.globalmaritimeforum.org/content/2020/01/Getting-to-Zero-Coalition_Insight-brief_Scale-of-investment.pdf).

16 *Id.*

Fig. 3: Hydrogen demand could increase 10-fold by 2050

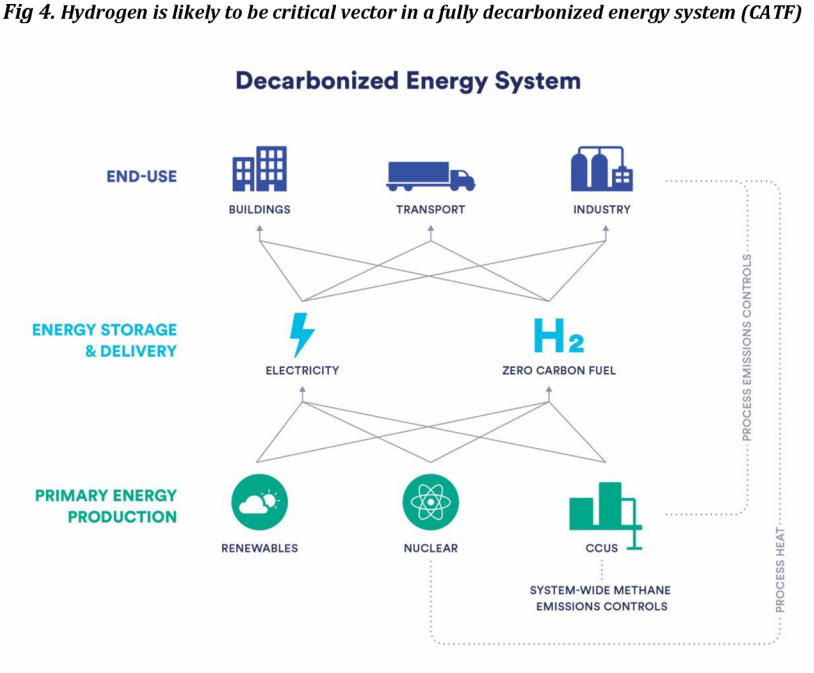


Energy-related demand for hydrogen from power generation, transportation, and other economic sectors could grow from 8 exajoules in 2015 to 78 exagjoules in 2050.

McKinsey & Company has estimated that a ten-fold scale-up in hydrogen production could be needed to meet future demand for hydrogen in a 2050 global economy that uses to hydrogen-based fuels to meet 18% of final energy demand.[17]

17 McKinsey & Co. for the Hydrogen Council, *Hydrogen Scaling Up: A sustainable pathway for the global energy transition* (2017) at 20 (https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf).

Fig 4. Hydrogen is likely to be critical vector in a fully decarbonized energy system (CATF)



Hydrogen (as well as ammonia made from hydrogen) can be produced from multiple zero- and low-carbon technologies and processes (e.g., electrolysis using renewable or nuclear energy, gas reforming with carbon capture), and can power a wide variety end-uses--particularly those that may prove difficult to electrify.

Although the vast majority of the hydrogen and ammonia currently produced is made through processes that emit significant volumes of carbon dioxide (CO_2), both molecules—hydrogen and ammonia—can be produced and used to carry energy through processes that emit little or no greenhouse gas.

Gas reforming with carbon capture and storage is one such process. Steam methane reformers (SMR) and similar technology decompose methane (CH_4) into hydrogen and carbon monoxide (CO) at high temperatures over a catalyst. A water-gas shift process then converts the CO into a stream of CO_2 and additional hydrogen. CO_2 generated in a process can be captured by a variety of commercial technologies, and geologically sequestered (CCS). The hydrogen or ammonia production would be low-to zero-carbon—assuming effective emission controls are put in place to significantly reduce methane leakage throughout the natural gas production, transport, and distribution system. Two commercial projects in North America already each capture more than one million tons of CO_2 per year from natural gas reforming hydrogen production, and additional projects are

under consideration.[18] By adding CCS technology to gas reformers and gradually increasing the capture rate, ammonia production can meet increasingly stringent greenhouse gas limits by incrementally reducing its carbon intensity.[19]

Electrolysis of water with zero-carbon electricity is another method for producing hydrogen without associated carbon dioxide emissions. Electrolysis uses electricity to split water (H_2O) into hydrogen and oxygen. If a zero-carbon power source is used to generate the electricity (*e.g.*, nuclear, wind, solar), the production of the hydrogen results in zero lifecycle carbon emissions. It currently costs more to make hydrogen with zero-carbon electrolysis than with SMR+CCS;[20] reducing that cost gap will require a significant global R&D effort aimed at making electrolysis less expensive. Furthermore, electrolytic production of hydrogen can be carried out at a range of different plant scales and is amenable to modularization. Reductions in the cost of zero-carbon electricity and thermal energy—for example, through advancements in nuclear power technologies[21]—could also play an important role in dropping the cost of electrolytic hydrogen production.

Using the Haber-Bosch process, hydrogen acquired through gas reforming or electrolysis can be combined with nitrogen (from ambient air, sometimes through air separation units) to make ammonia. This is a fully commercial process used at very large scale in the fertilizer industry today While hydrogen itself works well in some energy applications (*e.g.*, as fuel for on-road fuel cell vehicles), there are several energy sector-relevant applications where taking the extra step to make ammonia from hydrogen is beneficial. For example, ammonia is easier to store, especially in large quantities (it can be held and transported in modestly refrigerated tanks, whereas hydrogen storage requires deep refrigeration or significant pressurization). One practical implication of ammonia's advantage with respect to storability is that may make economic sense to move hydrogen energy across long distances (*e.g.*, from the US Gulf Coast to Japan) in the form of ammonia. Also, as discussed below, ammonia can be burned in modified or purpose-built internal combustion engines, which might limit the extent to which existing energy systems need to be wholly replaced.

Further deployment of low- and zero-carbon production of hydrogen and ammonia will likely require cost reductions in gas reformers, capture and sequester CO_2 equipment (including CO_2 transport infrastructure), and electrolyzers.

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18 Air Products, *News Release: Air Products Signs Agreements to Acquire Five Operating Hydrogen Plants for $530 Million and Long-Term Hydrogen Supply to PBF Energy* (2020) (http://www.airproducts.com/Company/news-center/2020/03/0330-air-products-to-acquire-hydrogen-plants-and-provide-long-term-supply-to-pbf-energy.aspx); Shell, Quest CCS Facility Captures and Stores Five Million Tonnes of CO2 Ahead of Fifth Anniversary (2020) (https://www.shell.ca/en_ca/media/news-and-media-releases/news-releases-2020/quest-ccs-facility-captures-and-stores-five-million-tonnes.html).

19 New ammonia plants can potentially reduce their CO2 capture costs by using oxy-fuel combustion to power their reformers. In an oxy-fuel combustion process, the fuel—in this case methane—is mixed with pure oxygen (rather than with air, which is mostly nitrogen). The result is a relatively rich and easier-to-capture stream of CO2. See CATF, Oxy-Combustion Capture http://www.fossiltransition.org/pages/oxy_combustion/113.php.

20 Cedric Philibert, International Energy Agency, *Electro fuels: An introduction,* at slide 8 (2018) (http://iealhydrogen.org/pdfs/1CedricPhilibert.aspx).

21 Lucid Catalyst, *Missing Link to a Livable Climate: How Hydrogen-Enable Synthetic Fuels Can Help Deliver the Paris Goals* (2020) (https://85583087-f90f-41ea-bc21-bf855ee12b35.filesusr.com/ugd/2fed7a_0d2e1cc06bff412cb3031fd4bdf93cb0.pdf); Energy Options Network, *Zero Carbon Hydrogen: An Essential Climate Mitigation Option-Nuclear Energy's Potential Role* (2020) (https://d1qndf3vop2l07.cloudfront.net/fresh-locust.cloudvent.net/hash-store/45b2875b85350e341a53d50425e4e3a9.pdf).

[3] Zero-carbon fuels can play a central role in the decarbonization of marine shipping

In 2018, the IMO adopted an initial greenhouse gas emissions reduction strategy that requires the marine shipping industry to reduce its greenhouse gas emissions at least 50% by 2050.[22] Although the IMO target falls far short of the obligation facing the shipping sector and other major economic sectors to fully decarbonize by mid-century, it nonetheless confirms the necessity of developing and deploying zero carbon fuels.

As an initial matter, the IMO 2050 target demonstrates the inadequacy of carbon reduction strategies that depend exclusively on efficiency improvements. According to the International Council on Clean Transportation (ICCT), "CO_2 intensity of many major ship classes decreased (i.e., they became more efficient)" during the two-year review period (2013-2015), but "total CO_2 and CO_2-eq emissions from ships increased."[23] Meeting even the IMO's 50% reduction target will require a shift to lower-carbon fuels.

But which fuels? Although liquified natural gas (LNG) provides some tangible environmental benefits such as lower emissions of sulfur oxides and particulate matter when compared to conventional marine fuel oil, it falls well short of the IMO mark for greenhouse gas reductions. The natural gas supply chain, as currently constructed and operated, emits substantial volumes of methane, a potent contributor to climate change.[24] Recent analyses by the ICCT and SINTEF Ocean AS have found lifecycle GHG emissions rates from LNG-fueled shipping to be as high or higher than the emissions rates associated with fuel oil and marine gasoil (MGO), respectively.[25]

Marine biofuels pose intertwined challenges of sustainability and scalability. If an energy source is going to play a leading role in the transition to zero-carbon energy, it must be massively scalable—but scale presents a unique set of problems for bioenergy. Even at its current size (approximately 3.5 quadrillion btu (quads) per year[26]), the global production of biofuel for transportation markets poses significant sustainability challenges, including significant lifecycle greenhouse gas emission from conventional biofuels; scaling up biofuel production to meet the projected energy demand from just the global marine freight sector

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22 International Maritime Organization, *UN Body Adopts Climate Change Strategy for Shipping* (2018) (http://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx).

23 Naya Olmer et al., International Council on Clean Transportation, *Greenhouse Gas Emissions from Global Shipping*, 2013-2015 (2017) (https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015).

24 See CATF, Oil and Gas Methane Mitigation Program (https://www.catf.us/educational/mitigation-program/).

25 Per ICCT, "Using a 20-year GWP … and factoring in higher upstream emissions for all systems and crankcase emissions for low-pressure systems, there is no climate benefit from using LNG [in place of residual fuel oil], regardless of the engine technology." Nikita Pavlenko et al., International Council on Clean Transportation, The climate implications of using LNG as a marine fuel (2020) (https://theicct.org/publications/climate-impacts-LNG-marine-fuel-2020). SINTEF Ocean AS analysis reached a similar conclusion when it reviewed a 2020 study by Thinkstep, finding that greenhouse gas emissions from LNG-fueled low-pressure dual fuel engines exceed those from marine gas oil-fueled engines. Elizabeth Lindstad, *Increased use of LNG might not reduce maritime GHG emissions at all* (2019) (https://www.transportenvironment.org/sites/te/files/publications/2019_06_Dr_Elizabeth_Lindstad_commentary_LNG_maritime_GHG_emissions.pdf).

26 International Energy Agency, *World Energy Outlook 2019*—Fig. 2-6.

in 2050 (approximately 13 quads per year[27]) could dangerously exacerbate those problems.[28] Waste-based biofuels present fewer sustainability problems, but aggregating highly dispersed waste feedstocks is complicated and expensive, and the shipping sector would have to outcompete the aviation industry (which has fewer decarbonization options than the shipping sector) for whatever volume of waste-based biofuel becomes available.

Ammonia is a particularly compelling candidate for fuel-shifting in the marine shipping sector because production of hydrogen and ammonia is massively scalable, in part because the ingredients for making the two fuels are readily obtainable and nearly inexhaustible; and because ammonia could be used as fuel in both purpose-designed and modified internal combustion engines (ICEs),[29] either neat or in a blend with petroleum fuel. Marine vessels are especially well-positioned to use ammonia-fueled ICEs because they can accommodate heavier engines and larger fuel tanks more easily; ports already site and build ammonia storage and handling equipment, thereby avoiding the chicken-or-egg problem that sometimes confounds the transition to alternative fuels in light-duty personal vehicles; and, unlike most light-duty vehicles, marine vessels are already fueled by professionals who can be trained to safely manage ammonia.

Numerous recent academic studies and industry reports confirm ammonia's potential as a key energy option for a decarbonizing marine shipping, including the following analyses:

- *Lloyd's Register & UMAS* (2020): "[A]mmonia produced from hydrogen, where the hydrogen is produced from NG [natural gas] with CCS, ... becomes the lowest cost zero-carbon option out to the 2050s. Furthermore, over time, the production and supply of ammonia can transition from NG to hydrogen produced from renewable energy, providing a more resilient long-term transition pathway."[30]
- *Alfa Laval, Hafnia, Haldor Topsoe, Vesta, Siemens Gamesa* (2020): "[A]mmonia is not only an attractive long-term solution for carbon neutrality but also can have a strategic role in the transition phase. By shifting gradually from fossil-fuel based ammonia to green ammonia, the CO2 footprint can be progressively lowered at low risk for the shipowner...."[31]
- *Shell* (2020): "Interviewees consider hydrogen and ammonia to be the most promising long-term fuel alternatives for shipping...."[32]

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27 US Energy Information Administration, International Energy Outlook 2019, *Transportation Sector: Freight Sector Energy Consumption by Region and Mode* (https://www.eia.gov/outlooks/aeo/data/browser/#/?id=51-IEO2019&cases=Reference).

28 See Reid WV, Ali MK, Field CB. The future of bioenergy. Global Change Biology (2019) 00:1–13 (https://doi.org/10.1111/gcb.14883).

29 See Agustin Valera-Medina et al., *Ammonia for Power*, *Progress* in Energy and Combustion Science (2018) 63-102 (https://www.sciencedirect.com/science/article/pii/S0360128517302320); MAN Energy Solutions, *Engineering the Future Two-Stroke Green-Ammonia Engine* (2019) at 5 (https://www.man-es.com/docs/default-source/marine/tools/engineering-the-future-two-stroke-green-ammonia-engine.pdf?sfvrsn=2b4d9d8a_10).

30 Lloyd's Register & UMAS, *Techno-Economic Assessment of Zero-Carbon Fuels* (2020) at 4 (https://www.lr.org/en/insights/global-marine-trends-2030/techno-economic-assessment-of-zero-carbon-fuels/).

31 Alfa Laval, Hafnia, Haldor Topsoe, Vesta, Siemens Gamesa, *Ammonfuel--An Industrial View of Ammonia as a Marine Fuel* (2020) at 6 (https://hafniabw.com/wp-content/uploads/2020/08/Ammonfuel-Report-an-industrial-view-of-ammonia-as-a-marine-fuel.pdf).

32 Shell, *Decarbonising Shipping: All Hands on Deck* (2020) at 19 (https://www.shell.com/energy-and-innovation/the-energy-future/decarbonising-shipping/_jcr_content/par/toptasks.stream/1594141914406/b4878c899602611f78d36655ebff06307e49d0f8/decarbonising-shipping-report.pdf).

- *MAN Energy Solutions* (2019): "Considering that the goal of IMO is to reduce the total annual GHG emission by at least 50% by 2050 compared to 2008 and, eventually, fully eliminate harmful emissions, the global maritime industry has to look into carbon-free fuels like hydrogen and ammonia … Ammonia constitutes a disruptive energy storage solution that can be produced using existing synthesis methods and storage solutions, and therefore has the potential to enter the market relatively quickly."[33]

Hydrogen itself could also play an important role in marine shipping decarbonization, especially for ferries and other near-shore vessels. Hydrogen fuel cell-powered ferries, cruise ships, and tugs are under development in California,[34] Norway,[35] Japan,[36] and elsewhere, and a recent study suggests that hydrogen fuel cell-powered vessels could be used for transoceanic shipping.[37]

Full decarbonization of the shipping sector requires not only ships that can run on zero carbon fuels, but also massive volumes of hydrogen and ammonia to be produced and supplied to ports around the world. In a report produced for CATF in Spring 2020, a team from Columbia University School of International and Public Affairs (SIPA) interviewed dozens of industry stakeholders and conducted detailed assessments of the capacity for zero carbon fuels storage at major port systems in the United States (New York/New Jersey, Houston, and Los Angeles), the Netherlands (Rotterdam), the United Arab Emirates (Jebel Ali), Japan (Keihin/Tokyo Bay), China (Hong Kong and Shanghai), and Australia (Fremantle, Darwin, others), and Singapore.[38]

The SIPA report outlines five "actionable steps that major market movers – shipping companies, oil and gas, policymakers, etc. – could take" to improve ports' capacity to deliver ZCF to the global fleet of transoceanic tankers, container ships, and bulk carriers:

Recommendation 1: Shipping regions, such as Europe, Southeast Asia, Asia-Pacific, or Northeast Americas, should establish trans-oceanic coalitions between government, energy industry companies, shipping companies, and financial institutions.

Recommendation 2: Shipping companies must partner with fuel suppliers aligned with the most relevant trade lanes through first-mover ports.

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33 MAN Energy Solutions, *Engineering the Future Two-Stroke Green-Ammonia Engine* (2019) at 5 (https://www.man-es.com/docs/default-source/marine/tools/engineering-the-future-two-stroke-green-ammonia-engine.pdf?sfvrsn=2b4d9d8a_10).

34 Sandia National Laboratories, *SF-BREEZE (*2020) (https://energy.sandia.gov/programs/sustainable-transportation/hydrogen/market-transformation/maritime-fuel-cells/sf-breeze/).

35 *Norway plans hydrogen network for ships*, The Motorship (2020) (https://www.motorship.com/news101/alternative-fuels/norway-plans-hydrogen-network-for-ships)

36 Martyn Wingrove, *Japan takes leap into hydrogen fuel*, Riviera (2019) (https://www.rivieramm.com/news-content-hub/news-content-hub/japan-takes-a-leap-into-hydrogen-fuel-56658).

37 Xiaoli Mao, et al., International Council for Clean Transportation, *Refueling Assessment of a Zero-Emission Container Corridor Between China and the United States: Could Hydrogen Replace Fossil Fuels?* (2020) (https://theicct.org/publications/zero-emission-container-corridor-hydrogen-2020).

38 Columbia University School of International and Public Affairs, *Zero-Carbon Fuels for Marine Shipping* (2020) (https://www.catf.us/wp-content/uploads/2020/06/2020_SIPA_Zero-Carbon-Shipping.pdf).

Recommendation 3: First-mover ports must work within their country or region to aggregate economy-wide demand for hydrogen fuels.

Recommendation 4: Fuel producers must coalesce around standard production methods for green hydrogen/ammonia while continuing to innovate.

Recommendation 5: Private and public capital must work with fuel producers to de-risk investments and lower the cost of capital for new fuel production and infrastructure.

Some of these recommendations—in particular, Recommendation 5—can be pursued in part by Congress and this Committee, and are aligned with the policies proposals described below in part 5 of this testimony.

[4] Zero carbon fuels can support decarbonization in a range of economic sectors

Zero carbon fuels can be used to accelerate the process and/or reduce the cost of decarbonizing a wide range of energy applications in addition to marine shipping. These applications include:

- Long-haul heavy trucking: Preliminary analysis by the National Renewable Energy Laboratory suggests that heavy-duty freight trucks could have a lower total cost of ownership when powered by hydrogen fuel cells rather than an electric battery alone.[39]
- Long-duration energy storage for electric grids with high penetration of variable renewable energy systems. Atmospheric pressure ammonia tanks (see Fig. 4) could promote grid stability by storing weeks' worth of zero-carbon energy, for use during dips in wind- or solar-based power generation or to meet demand peaks.
- Some industrial processes, *e.g.*, ironmaking, high temperature heating.
- Some medium transport, *e.g.*, long-distance buses, SUVs.
- Residential and commercial space heating: The use of hydrogen for space heating is currently limited by natural gas-hydrogen blend walls, but work is being conducted internationally to address these constraints.[40]

39 Chad Hunter and Michael Penev, National Renewable Energy Laboratory, *Market Segmentation Analysis of Medium and Heavy Duty Trucks with a Fuel Cell Emphasis* (2019) (https://www.nrel.gov/docs/fy19osti/73491.pdf).

40 See various publications from Hy4heat (https://www.hy4heat.info/reports).

Fig. 5. QAFCO Ammonia Storage Tanks - Messaieed, Qatar

Two 50,000 metric tons net capacity single-wall refrigerated ammonia storage tanks built by McDermott in Messaieed, Qatar[41]*; these tanks hold ammonia with an energy content of around 2 million MBtu. (Picture: HansonDoha)*

[5] Policy proposals and ideas for advancing the production and use of zero carbon fuels to decarbonize marine shipping

To address the massive scale-up challenge for zero-carbon fuels that is outlined in this testimony, Clean Air Task Force would like to submit the following federal policy proposals.

Clean Air Task Force recommends that the Senate immediately pass the American Energy Innovation Act of 2020. This package contains important provisions that would begin to expand research and development for zero-carbon fuels. In particular, the Clean Industrial Technology Act of 2019, which was cosponsored by the Chair of this committee which requires the Department of Energy (DOE) to establish an industrial emissions reduction technology research, development, demonstration, and commercial application program would make important strides for zero-carbon fuels, which have application in both shipping and industrial sectors. The technical assistance program to achieve emission reductions in nonpower industrial sectors could successfully pair with future additional federal policies and funding to support the development of zero carbon fuels in coastal states and municipalities around the country.

41 McDermott, *QAFCO Ammonia Storage Tanks* (https://www.mcdermott.com/What-We-Do/Project-Profiles/QAFCO-Ammonia-Storage-Tanks).

Beyond legislation currently under consideration in the full Senate, the Committee on Energy and Natural Resources can advance the production and use of zero carbon fuel in the marine shipping sector through measures that:

- Reduce technology costs by sponsoring research, development, and deployment (RD&D);
- Support markets with infrastructure and deployment policy; and
- Kick-start early projects with stimulus funding.

Research, development, and deployment. RD&D activity at the US DOE related to zero carbon fuel technologies could be greatly expanded. Several technologies relevant to marine shipping decarbonization deserve additional support, including: ammonia solid oxide fuel cells, ammonia reciprocating engines, large-scale ammonia cracking, high-temperature electrolysis, and advanced methane reforming.

Support for zero carbon fuel infrastructure and markets. Shifting the marine shipping sector (and other fuel-intensive sectors of the economies) to zero carbon fuels will require a systems approach involving federal support for fuel production, infrastructure build-out, and end-use technology adoption.

Fuel production and utilization support

Because zero carbon fuels are likely to cost more than incumbent high-carbon fuels at least for some time in many applications, policies should help catalyze market development through procurement incentives for zero carbon fuel-compatible energy and industrial end-use systems (e.g., dual-fuel marine engines that can utilize ammonia or fuel oil).

Production tax credits and/or 45Q-type policies should be created to mitigate the difference between market rates and production costs for zero carbon fuels.

Infrastructure build-out support

Policies need to help connect key production areas (*e.g.*, fossil, renewable, and nuclear resources in the Gulf Coast, the Marcellus region, the central Midwest, etc.) with ports and other demand centers such as Los Angeles and Long Beach, the Houston Shipping Channel, Chicago, and New York/New Jersey.

Infrastructure investments could include new dedicated pipelines, zero carbon fuel terminals, storage, etc., and repurposed existing fossil infrastructure.

The private sector alone is unlikely to invest ahead of need. Federal government could incentivize construction through measures such as tax credits pegged to the amount of zero carbon fuel moved through a new or repurposed pipeline (in which the value of the credit would be determined by the mass or energy value of the fuel moved divided by the fuel's carbon intensity).

Fuel production and utilization support

Because zero carbon fuels are likely to cost more than incumbent high-carbon fuels at least for some time in many applications, policies should help catalyze market development through procurement incentives for zero carbon fuel-compatible energy and industrial end-use systems (*e.g.,* dual-fuel marine engines that can utilize ammonia or fuel oil).

Production tax credits and/or 45Q-type policies should be created to mitigate the difference between market rates and production costs for zero carbon fuels.

End-use technology support

Zero carbon fuel end-use technologies will need supportive policies to help drive their adoption as production and infrastructure is developed. This could include, for example, rebates and incentives for appliances and vehicles, including marine vessels, trucks, and trains that utilize fuel cells, internal combustion engines, or turbines fueled by hydrogen or ammonia.

Kick-start zero carbon fuels and transportation. Stimulus funding should promote zero carbon fuel for marine shipping through the following initiatives, which could also open up new job sectors in the United States:

In order to build out a zero carbon fuels system, we need to develop the key interconnected components of production, transport and end-use at the same time. Therefore, policy should focus on catalyzing zero carbon fuels regional hubs.

Ammonia Hub

Hubs could include a combination of production, transport and endues technology options. A hypothetical hub in the Gulf Coast region could have the following characteristics on the ammonia supply chain:

- Production: methane reformer and ammonia synthesis loop; >90% carbon capture and sequestration across system; ammonia output: 1 million MT per year[42].
- Transport: Five-mile ammonia pipeline from production site to portside storage, loading, and fueling terminals.
- Use: Decarbonized ammonia, in the form of fertilizer or marine fuel, would be delivered to agricultural sector consumers willing to pay a premium to reduce carbon intensity of fertilizer, and to ammonia fuel-compatible marine vessels.

To catalyze the development of these types of hubs, federal support could cover low-interest development loans and cost-share grants to build help build initial infrastructure and end-use transport vehicle fleets. Production tax incentives, or other types of deployment incentives could mitigate the difference between production costs for the fuel and the market rate.

42 Hubs could be used to promote the development of multiple hydrogen and ammonia production pathways (e.g., electrolysis using variable renewable energy, electrolysis using nuclear power and thermal energy).

The CHAIRMAN. Thank you, Mr. Lewis. Thank you, all, for your testimony this morning.

Mr. Davies, I want to start my questions by noting one of your comments that when we are talking about marine hydrokinetic energy you think about the power of the tides of our rivers, but also the reliability of that. I mean, you look at your tide book, we can tell you when the tide is coming in. We can tell you when the tide is going out, and I don't think there has been a day that I have been on this planet that the tide has not come in and gone out. To me, that is pretty reliable.

So when we think about that as a baseload power source, I think it is important to recognize how it has been, kind of, sitting out there on its own for quite a period of time and the attention that we are able to focus on it, not only through the private sector but through our government agencies, I think, is important. You note that the Title 17 Loan Guarantee Program has some opportunities but that in order for it, really, to work for companies such as ORPC, when you are a smaller project, when you are a smaller program, it is competitive. So I am intrigued by your idea of a carve-out of those funds that would go toward smaller entities.

But you also mention in one of your recommendations that we need to look to streamlining the regulatory process and you note that it took seven and a half years for a FERC license. I would like to bring Dr. Cruickshank into this conversation with you on what we might be able to do to shorten that permitting process, especially for pilot projects, and then to the issue of the level of cooperation between FERC and state governments on permitting these projects. I am trying to understand if there are some areas here that we can allow for a more efficient process out there. Mr. Davies, why don't you start off and then Dr. Cruickshank, if you can speak to this?

Mr. DAVIES. Sure, and Senator, thank you for the question. I think when we talk about our projects, you know, the first time we put a device in the water is also the first time for regulators seeing those devices. So I think there's naturally going to be delays as, you know, not understanding what an MHK device is and what the potential impacts are around it. There's a steep learning curve for regulators there. And so, I think the natural tendency is to go take the most conservative position that a regulator could take. I think one of the—the hydropower industry had some of these challenges.

And I think, I can think of three steps. Back in 2013 there was the Hydropower Regulatory and Efficiency Act that was passed that really streamlined the process for permitting and licensing for new hydropower projects. I think having a similar legislation like that for MHK that would streamline, it would not only streamline the federal process, but I think it would align, enable state and local regulators to align their policies with that policy so it would actually act as a guiding document as well. And then finally, I think one of the most effective things is to put devices in the water. I think the more devices that are in the water, regulators from various states and jurisdictions can understand how regulators in other jurisdictions, you know, dealt with getting device in the water and what, if any, you know, we believe there's little to no impact from our devices, but to actually experience that and see

what, how other regulators, you know, worked to approve those processes, we think will streamline our process as well.

The CHAIRMAN. Dr. Cruickshank.

Dr. CRUICKSHANK. Thank you, Senator, for that question.

We have an MOU in place with FERC so that we can cooperate on any marine hydrokinetic energy that'll be on the Outer Continental Shelf. As I mentioned, we're responsible for issuing the leases and FERC will license the actual project itself. We've worked together closely to try and develop a process that we believe can be efficient but, as Mr. Davies noted, there will be challenges whenever there is something being installed for the first time as stakeholders and regulators try to understand what it is they're dealing with and how it will work. And I also agree with him that as more of these get into the water, a lot of those questions will be answered which will allow the process to really work as efficiently as we've tried to design it to be.

The CHAIRMAN. Well, my time is expired on this round, but I think it is one of those where we recognize that we have the federal regulators, we have the state and those who are trying to advance the project. You also have tribal interests in our state, but recognizing that there is a level of cooperation, collaboration, working together rather than a more siloed approach that, I think, historically we know exists, could be helpful.

Senator Manchin.

Senator MANCHIN. Thank you, Madam Chairman.

This will be for Mr. Simmons and Mr. Lewis. Maritime shipping is projected to potentially triple in the next 30 years which will require alternative fuel options to reduce the environmental impact of increased ocean freight. I understand a low emission vessel must be commercially available by 2030 to meet the international maritime organization's reduced emission goals. As we are today, several officials in DOE are investing in research and development to help develop alternative fuels, including ones that could accelerate this timeline. So Mr. Simmons or Mr. Lewis, are we on track to meet the industry needs of commercially viable, low emission vessels in ten years?

Mr. SIMMONS. I don't know is the safe answer. We are—so our Bioenergy Technology Office is looking at, you know, has a new focus on heavier fuels such as biofuel for jets.

Senator MANCHIN. Sure.

Mr. SIMMONS. But also, for biofuel for these heavy applications for marine as well as if they are from, like if it is like ammonia, I don't think we would get there. If we can get there with a biofuel that is a heavy biofuel than we could do that if it's a pure drop in fuel within ten years.

Senator MANCHIN. Which low carbon technologies do we need to be investing in the most to be, to meet these goals?

Mr. SIMMONS. Well, I'd like to hear from Mr.——

Senator MANCHIN. Mr. Lewis?

Mr. SIMMONS. I forgot his name. Mr. Lewis. His thoughts on that.

Senator MANCHIN. Okay.

Mr. SIMMONS. But definitely on these heavy biofuels is very important but also in, as in ammonia. That's also a critical technology.

Senator MANCHIN. Sure.

Mr. SIMMONS. And because it's a hydrogen carrier.

Senator MANCHIN. Mr. Lewis, your input, please?

Mr. LEWIS. Yes, thanks for the question.

We think that biofuels present some sustainability and scalability problems, and they're also going to face serious competition from the aviation sector. So as mentioned in my testimony, we think that ammonia is going to play a critical role in decarbonizing the sector. There's work being done on a handful of different fronts, at universities around the world, including the University of Minnesota and Texas Tech on ammonia fuel internal combustion engines.

And there's work going on in the marine space. MAN Energy Solutions is designing new ammonia-compatible duel fuel engines and developing the capacity to retrofit its existing engines which it says powers half of global marine freight around the world. The company has said that it can deliver ammonia-compatible engines to the market by 2024. Other engine developers such as Würtsilä and Samsung Heavy Industries are also moving in this direction and American engine companies are also well-positioned to advance the development and deployment of these engines. Caterpillar, for example, filed a patent application for an ammonia fuel engine in 2008, so they should be ready to move forward as well.

Senator MANCHIN. And this would be to all the witnesses or someone who has not spoken yet. Europe has led the way for manufacturing and building offshore wind projects. Given the size of those turbines, it seems to me it would not only make sense to build them here at home for U.S. projects but it would also present an opportunity to reinvest in our ports, shipbuilding and domestic workforces, the same should be said for marine energy technologies and low-carbon shipping fuels as we just spoke about. I think West Virginia's industries could also help boost some of these efforts by using our own natural gas resources to make hydrogen or ammonia for the shipping.

I have been working with my friend, Senator Stabenow, to revive and retool the 48C Energy Manufacturing Tax Credit. To what extent would that help support new domestic job creation here in the U.S. and advance our efforts, the efforts you are all working on?

Anybody want to take that one?

Well, what other policies——

Ms. KINDEM. I can, please.

Senator MANCHIN. I am sorry, please.

Ms. KINDEM. I may start?

Senator MANCHIN. Yes.

Ms. KINDEM. Okay, thank you.

It's a good and valuable question and however, I will, but we all know this offshore wind is a new industry in the U.S. and we are benefiting from a lot of experience that we have in Europe. And even though it's extremely important that we are building up that support and supply industry also in the U.S. And in a way we want to leverage the opportunities we have in the U.S. as we are moving

forward and that's, also, you know, of course in the U.S. and also, we are familiar with the supply chain also in the—so I think it is something we'll be able to pull off. These projects are still immature from our side but we are moving forward and——

Senator MANCHIN. Ms. Kindem, are you all doing any——

Ms. KINDEM. ——you know, going forward like that.

Senator MANCHIN. Excuse me, I am so sorry. Are you all doing any manufacturing in the U.S. now?

Ms. KINDEM. We have not started. We have not come that far from the ITC. We have not even sold manufacturing. But we are in the process now as early stage project of doing, kind of, the tenuring process and then you get into details. I can't share with you, but I assure you this is high on our agenda when we moving forward with these proposals.

Senator MANCHIN. Do any of you know, is there any manufacturing on offshore wind projects in the United States? Any of that technology?

Dr. CRUICKSHANK. Yes, Senator, there has been. It is, it has not been the turbine blades or the cells at this point, but for instance, for Block Island, the foundations for each of those turbines was built at Gulf Island Shipyard in the Gulf of Mexico and there are a lot of agreements that have been put in place for projects that are still in the design phase that would have foundations and supply vessels and various other components manufactured here in the United States. And I think that some of the larger pieces of equipment will come along when there are enough projects in the pipeline to support investment in that supply chain.

Senator MANCHIN. Madam Chairman, if I could just indulge with one more question, just real quick?

Most, for offshore they are telling us that they utilize the gearbox drive generator. Offshore wind mills rely on a very powerful magnet as a key component in a direct drive generator. You all would know more about the technology here. A direct drive generator is more suitable to offshore wind due to its low maintenance requirements; however, it also creates supply chain vulnerability because the magnet is derived from a rare earth mineral called neodymium which is mined almost exclusively in China. The wind turbines on the Block Island Wind Farm off the coast of Rhode Island are equipped with a magnet that was made in Japan out of rare earth minerals originating in China.

So we have held several hearings in the Committee about the monopoly China holds over the supply chain of rare earth elements. Is this a tremendous obstacle for us to be able to successfully manufacture in the U.S. because of our dependence on China on rare earth minerals? Very quickly.

I am sorry, take more time.

Mr. SIMMONS. Well, that could be a long answer, but——

[Laughter.]

——and we will happily answer, give a more——

Senator MANCHIN. I guess the quick answer would be sourcing from China. Does that create one heck of an obstacle for you?

Mr. SIMMONS. It does create an obstacle and we are doing a number of things to overcome that obstacle, including there is a project

that we're funding from GE to look at a super-conducting generator that wouldn't need any rare earth magnets. So there's——

Senator MANCHIN. We will get into that——

Mr. SIMMONS. We're happy to give you plenty of information on the subject, yeah.

Senator MANCHIN. Okay, thank you very much. Thank you all. Thank you, Madam Chairman.

The CHAIRMAN. Thank you, Senator Manchin.

Senator Cassidy was next on our side. It looks like he has dropped off the line, and Senator Gardner was following him. I don't see either of them. If either one of them comes back on we will turn to them, but in the meantime let's go to Senator Cantwell.

Senator CANTWELL. Thank you, Madam Chair, and thank you and the Ranking Member Manchin for holding this important hearing. As a proud coastal state, our economy on the coast is very important to us. My constituents probably don't even know that our coastline generates a tremendous amount of pollution-free electricity. According to analysis there is over 120 gigawatts of offshore wind potentially along the Washington State coast and almost 200 terawatts of resources off our coastline that could be, could generate, I should say.

So Washington is also the home to the Marine and Coastal Research Laboratory in Sequim, which is part of the Pacific Northwest National Laboratory, and I know that some of you are very familiar with that. We think this research center is very important to us in the research that we are doing on these offshore resources. Mr. Simmons, could you comment on whether you support the $10 million currently allocated in the energy area of energy and water appropriations for this kind of R&D? And you recently visited there and met with a lot of the regional experts. What do you think we should be doing in addition to accelerate the innovation that they have been working on?

Mr. SIMMONS. We are strong supporters of the laboratory. The new name confused me a little bit. But it was—I had a great visit there last year. I was very happy to have the opportunity to go see the work that they're doing. There's a lot of opportunities in, especially as one of the Powering the Blue Economy Initiative from our Water Power Technology Office because they're our only coastal laboratory of any of the, of any parts of the national laboratories so that they are well positioned and they have great experts that—well positioned physically, geographically and as well as having experts in this area that can really contribute to the blue economy overall, but also to next generation ocean technologies.

Senator CANTWELL. Well, I was thinking about just this level of commercialization which is always an issue, you know, on the R&D side, protect transfer. Do you think that there are legal or jurisdictional barriers? I mean, should we be working more closely with FERC and NOAA and Ocean Energy Management to try to tackle some of these issues?

Mr. SIMMONS. Yes, we, I mean, as Mr. Davies noted when it was seven years to get a FERC permit, I think that that is, that is challenging. That is super challenging when it comes—anything that touches the water, the regulatory process is long and we need to

do whatever we can to streamline that process. We try our best to work with Department of Interior, with the regulators in this area to do research to help them, as well as some work with FERC, to have as expedited a process as possible, but it is an area that we definitely need to focus on.

Senator CANTWELL. Thank you.

Well, we will follow up with you on that, and I would certainly like to invite the Chair and the Ranking Member to come and visit the facility. It really is quite an amazing facility, probably not visited much by members of this Committee, but the technology is amazing and the site itself is breathtaking.

On fuel issues which several of my colleagues have pointed out, in my state, Washington Ferries announced last summer that they will gradually move to electrification of the fleet with the replacement of 13 diesel ferries with hybrid electric vessels and the conversion of six other plug-in hybrids. I know I have visited some of our shipbuilding facilities in the state who are building these electric ferries for other parts of the United States, very easy on load, off load, commuter, passenger ships. Where should we be going in further incenting that? And I know a lot of your work is on the R&D side, but there are members here who obviously have to think about these things from all our committee jurisdictions.

Mr. SIMMONS. That's a tough question for me when it comes to further incentivizing it. There is definitely research that needs to be done in terms of how do we charge, I mean, the ferries use an amazing amount of energy. When I went on the same trip, I had the chance to tour one of the ferries and we went down into the engine room. It is a huge vessel and which, so when that pulls in and is connected to the dock, it is a lot of electricity that is flowing very quickly. That is a serious challenge for batteries to be able to take in all that electricity. It degrades the battery. So, like, it is a—there are definitely R&D challenges to further that, to further that technology, but it is rather exciting.

Senator CANTWELL. Well, just like you had mentioned on, you know, FERC and other offshore, I think a similar kind of collaboration between agencies on vehicle transformation to alternatives would be great.

So thank you, Madam Chair.

The CHAIRMAN. I might come and see those electric ferries too.

Senator CANTWELL. Yes.

The CHAIRMAN. Yes, lots to see out there.

We have Senator King, who is with us remotely.

Senator KING. Thank you very much, Madam Chair. This has been a fascinating and really important hearing. I am forced to mention up front how much Maine is involved. ORPC, who is with us here today, is based in Portland, Maine, and the country's first floating offshore wind project, Aqua Ventus, is on track to move forward in Maine in the next couple of years. So I really want to thank you for this important hearing and also brag a little bit about the role that Maine is playing in this development.

I can't emphasize enough how important the federal investments in research are. The model is the development of hydrofracking technology which was supported by federal research. It was not economically viable at the beginning, but, of course, now we know

that it is. The same thing with solar and wind. The price has gone down tremendously in the last ten years and it was the federal research support, as I think Mr. Davies mentioned, that had a lot to do with developing the technology, the infrastructure, the supply chain that enabled that to happen. So I want to thank Dan Simmons, he has been to Maine, for the work that they have done, for the support they have given to our Aqua Ventus offshore wind project because the very first Ford built by hand was pretty expensive. Now they can build Fords at very reasonable prices because of the development of demand and the supply chain and the infrastructure. So I think that is an important point.

I wanted to ask Dr. Cruickshank about if there is research being done in connection with other agencies on fisheries impacts. We have a very vigorous fisheries industry in Maine, as they do in Alaska, and our fishermen are going to want to know what are the impacts, what are the implications? I would also like to ask our friend from Equinor to give her thoughts as to what has been the impact, if any, on fisheries on the offshore project in Scotland.

So Dr. Cruickshank, any thoughts on that issue?

Dr. CRUICKSHANK. Yes Senator, thank you for the question. We have funded quite a lot of fisheries research from BOEM's environmental studies program. In fact, we've funded about 22 fisheries-related studies along the Atlantic that have tried to capture baseline information on fisheries' movements and fisheries' habitat as well as studies focused on the impacts of sound in the water and electromagnetic fuels. So we have been doing our best to try and learn what impacts the construction of these facilities may have. We are also partnering with National Marine Fisheries Service to conduct research, and we've entered an MOU with them and with the Responsible Offshore Development Alliance which is a consortium of commercial fishing interests to try and identify information gaps and focus research on filling those gaps. And as a matter of fact, the three of us are co-hosting a workshop next month on the state of the science of fisheries as it relates to renewable energy so we can further those efforts.

Thank you.

Senator KING. It is going to be important to continue that work so that when we are moving closer to deployment, we don't have to start afresh on the research. I am glad to hear about that.

Ms. Kindem, on the Equinor project, number one, are you seeing fisheries' effects and, number two, is the power coming ashore A/C or D/C? I understand there is less EMF issue with D/C and there are some other advantages. What is the technology that you are using there?

Ms. KINDEM. Well, thank you for being interested in Hywind Scotland and floating wind. I think this is a fantastic technology for the future and, for us, it's extremely important to work with fisheries in general so we, you know, if we're talking the U.S., I will say we have a tremendous amount of meetings with fisheries to listen to them and ensure that their interests is also being followed. So this is the balancing act where we're working hard with them. It's the same thing, approach, we've had with also the Scotland project.

So the Scotland project is, you know, has been operating for many years now. It's off the coast of Scotland. It's set at five turbines and in a way it was important for us, it was a research project in itself because this is not only about having one turbine, but it's having——

Senator KING. That is a floating project, right?

Ms. KINDEM. It is really a floating project and this is the first time we, it is not a one-of-a-kind installation, but this is a five turbines and then you have to, you know, you are testing a lot of things. You're testing the interactions between these turbines, which is extremely important for us. Then also it's important that you continue to have the dialogue with the fisheries as we're doing, you know, in either it's the scope and all we are doing at the moment also in the U.S. and for us, it's extremely important. We've been, if you look at Empire project, which is, kind of, the first project to come along in the U.S. We've spent a lot of time through the, you know, working with water too and having discussions there to ensure that some of the layers that also could be adjusted according the fisheries and I think——

Senator KING. Well, let me interrupt for a minute, just because I am running out of time.

Ms. KINDEM. Sorry.

Senator KING. But have there been substantial fisheries impacts that have——

Ms. KINDEM. We haven't heard of any substantial—we haven't heard of any substantial fishery impact. What I would like is to follow up with you after. I can give you some details on the work we've done on Hywind Scotland, on—I'm sure that would be of interest for you and then we can give more of the details both on the fisheries and also on the technologies included in that.

Senator KING. And is it D/C or A/C coming ashore?

Ms. KINDEM. I must say it's, I think it's A/C, but then again, I think I'd have to give you the details again. It's a long time since I've worked with the Hywind Scotland, but I can assure you I can give you the details.

Senator KING. Thank you.

Madam Chair, thank you very much. I hope we will have a second round. I have a few more questions. Thank you.

Ms. KINDEM. Thank you.

The CHAIRMAN. Absolutely, thank you, Senator King.

Senator Cortez Masto.

Senator CORTEZ MASTO. Thank you. Thank you for this conversation. I, too, find it very interesting and a great opportunity here in the United States.

Mr. Lewis, in your testimony you note that two of the most promising shipping fuel options are ammonia and hydrogen. So what economic opportunities do hydrogen and ammonia fuels provide for non-marine states across the country, like Nevada, where we are focusing on a robust, renewable energy portfolio? I am just curious if you have any thoughts about that. And that would be for Mr. Lewis.

Mr. LEWIS. Yes, thank you for the question. We think there are significant opportunities for inland states because producing enough zero carbon fuels for the marine sector and other sectors is

going to be, sort of, an all-hands-on deck requirement. A key attribute of hydrogen and ammonia fuels is that they can be produced and used in so many different ways. We think it's likely that scale up of zero carbon hydrogen production is going to be achieved through the use of expanded renewable energy power, nuclear power and gas reforming with carbon capture. So, some of the jobs associated with this scale up involve new technologies and new skill sets while others are going to be pretty similar to jobs that already exist in the petrochemical industry. Ultimately, we're going to need to produce liquid and gaseous fuels for using technologies that are similar in many ways, the conventional refineries, but do a better job managing carbon flows. Those are large installations that require lots of people to build and to run them.

We're going to also need——

Senator CORTEZ MASTO. Thank you. Oh, sorry, go ahead.

Mr. LEWIS. I was just going to say, we're also going to significantly need to expand our distribution from places like Nevada to ports and other demand centers around the country. So that means building a lot of pipelines, storage tanks, fueling terminals and lots of jobs building, servicing and operating that equipment.

Senator CORTEZ MASTO. And thank you, because that was my next question for you, you segued perfectly, is the workforce and the opportunity to, as we were coming out of this pandemic and we are dealing with the economic crisis and a lack of jobs, there are jobs of the future in this space. And you know, I find it interesting prior to the pandemic nearly 3.4 million Americans worked in the clean energy industry and as such, the Bureau of Labor statistics projected in 2019 that wind turbine technicians would be one of the nation's fastest growing jobs over the next decade.

So let me open it up to the panel because I do think there is the opportunity to start focusing on how we start transitioning, how we really rebuild our workforce and include this new technology. I would love to open it up to you and get your thoughts on that. Let me start with Ms. Kindem. I am curious how we should be looking at this at the federal level to continue to support our workforce as well.

Ms. KINDEM. I think this is a very good point to put forward on the local workforce and you know, that have become created on Empire Wind. We have a local continent that we've got to live on and you know, and then you get the local workforce which is going to be really part of that. So we are planning the sector, you know, the operations, that's going to be a base, of course, and technicians and we have also to have to work on educating them to ensure they are on proper skills proper for working. So I think this is going to be some of the most important tasks we're going to have as an industry. It's really kind of the upscaling of the workforce and ensuring that we have the technicians available and, then again, this is going to be what's part that's going to buildup of the industry.

Senator CORTEZ MASTO. Thank you.

Mr. Simmons, can you talk a little bit about that? What is DOE doing to continue to further incentivize the expansion of our workforce, the transition of our workforce in this space?

Mr. SIMMONS. We have a number of programs focused on, focused on workforce, we're focused on workforce training. Earlier

this year we announced a $20 million award to the University of Tennessee that is focused on these jobs, these energy jobs of the future. All of our, just about all of our programs have some aspect of workforce training in them. It's very important, obviously, you have to have people that understand the technology so that we can grow the technologies, that that is, that is a key part of the technology itself.

And if I may, about the previous question, about Nevada and hydrogen, our H2@Scale concept which is using hydrogen in all the possible ways that we think that we can use it, definitely applies to Nevada where you could use hydrogen as a storage medium. You could also use, hydrogen can power combustion turbines. In fact, there is a project to do that, not that far across the border, in Utah at the Intermountain Power Plant, to have a combustion turbine that is at least partially powered by hydrogen and hopefully, at one point, 100 percent hydrogen. So I just wanted to make sure to get that in because it's—hydrogen has very important aspects onshore as well.

Senator CORTEZ MASTO. Thank you. Thank you all.

The CHAIRMAN. Thank you, Senator.

Let me go back to you, Dr. Cruickshank and this will be a discussion, a little bit here, about wind energy permitting. You spoke in your opening statement about the interest, I think you mentioned some 16 active wind leases right now. It is clear that there is a market for competitively-priced offshore wind here. I am happy to hear that BOEM has been able to keep on track with its December timeline for the Vineyard Wind Notice of Intent.

I worry though about, again, permitting and timelines and delays and potential delays for future Notices of Intent. Why don't you talk to me about whether or not you anticipate regulatory delays for other offshore wind projects similar to those that affected Vineyard Wind. Do you think that we have the necessary staff to meet the timelines? How do you feel about just where we are with a somewhat predictable timeline or is it predictable at this point in time?

Dr. CRUICKSHANK. Thank you for that question.

I believe that we will become more predictable over time. The Vineyard Wind Project being the first of its kind in U.S. waters has certainly raised a lot of issues that we've needed to work through with other users of the ocean. It's important to the Secretary of the Interior and to us at BOEM that this first decision be right, and by that I mean it finds a way to have a project that allows successful co-existence of offshore wind and commercial fishing and maritime navigation—it does not have any unintended environmental consequences.

And I think, as we work through the Vineyard Wind Project and get to our answer there, that our decision on that will be guidance for us at BOEM for how to work through other projects so they will be able to work on a, we will be able to work through them on a more predictable timeline. I would also note that the supplemental EIS we did to try and get a broader look at how to build out of offshore wind in the U.S. would impact the environment and other uses is a document that will help support a number of analyses for a number of other projects that we will have in the future.

As far as resources, I think that Congress has been kind to us and meeting our needs and we hope that the FY 2021 budget that the—and the requests that the President sent up certainly would provide us the resources we need to be able to meet our responsibilities in permitting these projects.

The CHAIRMAN. So it sounds like you think you have the necessary staff. Would you support implementing a more predictable lease schedule offshore wind options similar to what we do currently for oil and gas development? Is that something that you will look at? What do you think about that?

Dr. CRUICKSHANK. It is something we consider. At this point we have really tried to build our leasing process through working closely with states and other federal agencies and other stakeholders in the ocean to work on a state-by-state or a regional scale now to try and identify areas that are suitable. I think that if we tried to put out a program right now before we have much experience with these projects in the water, that we would really be running into a lot of questions. It would make it difficult to design a program of a national scope like we have for oil and gas.

The CHAIRMAN. So let me turn to you, Assistant Secretary Simmons. The Water Power Technologies Office R&D initiative of Powering the Blue Economy, it has identified these isolated communities, and again I think about Alaska's situation. You have a situation where you have a market there of all these isolated communities of more than 70 megawatts. What efforts are you making within the Department to work directly with these local communities, these smaller communities, to expand the resources and as we think about these energy transition opportunities, particularly for the islanded communities that we have and not just in Alaska, but Hawaii, certainly Maine, as Senator King has mentioned? What are we doing to facilitate that level of outreach and communication?

Mr. SIMMONS. We have a number of things that we are doing that, you know, the Powering the Blue Economy initiative is pretty new, but you've heard about one of the things that would fit into this concept with the work that ORPC is doing, for example, at Igiugig. We also had another aspect of that is the Waves to Water Prize that we announced last year to use the mechanical energy of wave power to drive desalination for some of these communities. Also, one of the things that we are very excited about is that next month we are going to be announcing the selections of our Energy Transitions Initiative Partnership Project, I think is the name of this initiative.

And so, we have the—for a number of years we've had the Energy Transition Initiative that works with island and remote communities. What we have done differently is we took that effort and we included additional monies from the Water Power Technology Office and the Solar Energy Technology Office to fund, to be able to fund more projects. We're going to make those selections next month, about mid-month, hopefully. That's the current plan, where we'll fund about five partners to provide multi-year support to provide technical assistance to these communities as well as to provide a platform for information sharing because well, like, in one way, all remote communities are different, in another way, they're all re-

mote and they all have similarities. So ways that we can build on those similarities and share information from, you know, from the Caribbean, to island communities in the far Pacific, to Alaska or Hawaii. So we're very excited to when those selections will be made and looking forward to being able to do that next month.

The CHAIRMAN. And we will look forward to hearing about those.

Let's turn to Senator Manchin.

Senator MANCHIN. Very quickly, I just have one question.

With Puerto Rico receiving $9.6 billion, which has just been announced for the grid, are you all working on any types of this technology, ocean technology or the wave technology or all the things we are talking about that would be more reliable for them if that is going to be that kind of investment rather than a system that basically goes down every time they have a storm? Anybody want to talk to that one?

Mr. SIMMONS. I'll speak to it quickly and just that at the Department of Energy our Office of Electricity is spearheading the work with Puerto Rico and some of, some people from my office have worked with the Office of Electricity. So——

Senator MANCHIN. Are they prepared now, I mean, with this slug of money coming, $9.6 billion has just been announced. Are you ready to, are they ready to implement this? Ready to go with it?

Mr. SIMMONS. That I don't know.

Senator MANCHIN. Does anybody know about Puerto Rico?

Dr. CRUICKSHANK. I can't speak to the spending of the money, Senator, but I would note that the Outer Continental Shelf Lands Act does not have jurisdiction offshore of Puerto Rico or any of the territories or possessions. It's limited to the 50 states. So there could not be any leasing for such projects in federal waters offshore of Puerto Rico.

Senator MANCHIN. Anybody else have any knowledge of anything going into Puerto Rico? I mean, it is an awful lot of money to be throwing at that when we have a vulnerable system there and if it is not hardened or other types of reliability, it is going to be something we are going to repeat. It is something we would like to look into maybe. Maybe we can get some information. DOE, you would have the best ability to get that information.

Mr. SIMMONS. Sure. Yeah. We will get you additional information on that.

Senator MANCHIN. Would you pull it all together? Tell us how they intend to spend that $9.6 billion?

Mr. SIMMONS. Yeah, yes, we will do that.

Senator MANCHIN. Thank you. That is it, Madam Chair.

The CHAIRMAN. Senator King.

You are still on mute here.

Senator KING. Thank you, Madam Chair.

The CHAIRMAN. There you go.

Senator KING. The question I have is talk to me, briefly, I mean, we have limited time, about the difference between ammonia and hydrogen, what the advantages and disadvantages are in terms of generating the fuel, storing it and deploying it.

Mr. LEWIS. Thanks for the question.

So whether we're making hydrogen neat for use in fuel cells or ammonia for use in internal combustion engines and other systems,

we start with hydrogen and we want to make the hydrogen without carbon. But the difference at that point, whether or not you keep it as hydrogen or turn it into ammonia, depends on your intended application.

So ferries, which were discussed earlier, are potential terrific users of hydrogen-based fuel cells because you are working in a near shore application. You're not trying to cross the ocean. You can refuel more frequently. If you're trying to cross an ocean you need something that's a little bit more energy dense. It's easier to store. And ammonia is much easier to store, especially in large volumes than hydrogen.

Senator KING. That was going to be my next question. Give me a comparison of energy density between ammonia and diesel fuel, for example.

Mr. LEWIS. It's about, ammonia has about half the energy density of diesel fuel because the——

Senator KING. And is it used and stored on an internal combustion situation in a liquid form?

Mr. LEWIS. Yes, yes——

Senator KING. And so you need larger tanks as it sounds like it.

Mr. LEWIS. You would need, you'd need a larger tank that is slightly refrigerated. There are engineering firms and shipbuilding firms around the world that are working on mitigating that challenge and they think they see paths forward.

Senator KING. And you mentioned, I think, briefly, can current diesel engines be retrofitted to use ammonia?

Mr. LEWIS. We think so. We're very eager to see some of the first commercial applications of that, but there are several companies around the world, again, that are working on that because these are, you know, these are large engines and significant investments and it would be great if we could take the existing fleet and make it ammonia compatible.

Senator KING. So, the idea is hydrogen and ammonia generated by renewable power offshore, you could generate it during periods of light demand at night, for example. It would be a use for that power which would otherwise be surplus. Is that correct?

Mr. LEWIS. That would certainly work. We think there's a lot of different ways to make zero carbon hydrogen whether it's from renewables, whether it's from nuclear, whether it's from steam-methane reformation with CCS, all of these technologies, though, need DOE investment to really be unlocked.

Senator KING. Madam Chair, I want to thank you for this hearing. I feel like we are literally seeing the future here. And of course, I have to mention that all of our problems may be solved today. Elon Musk has called today Battery Day, so who knows what they are going to be announcing in terms of battery capacity and longevity and energy density. So a great day on this subject. It is a very exciting future.

I was really struck by the figure of 80 percent of our electricity demands reside along the coasts and along the shores of the Great Lakes. Huge opportunity here with existing transmission and distribution infrastructure. Exciting stuff.

Thank you very much, Madam Chair, for holding this hearing.

The CHAIRMAN. Well, thank you, Senator King, I agree. It is exciting stuff.

I have just a couple more questions. Other members have dropped off the line, so I will be quick in wrapping up here. Ms. Kindem, I wanted to ask you a question. There was a recent Executive Order (EO) from the White House that prohibits oil and gas leasing activities in federal waters in the Eastern Gulf, in the Straits of Florida and Southern Atlantic. Do you expect that that EO could affect the offshore wind industry's access to develop in those regions? Have you given any thought to that?

Ms. KINDEM. I think this is something we're evaluating what this truly means. If it's also offshore wind and not only oil and gas and I guess I need some expert to help me on responding of that. But I guess I can respond a bit more general that I think if it's a good area for a lease or not, I think that's more dependent on, you know, specific topics and not like a general order. So I think this is more, if it's a good lease area, I think that should depend more on that it could be geology, it could be on the state for the input, you know, different topics and not like a general order. So I think that's our general view on that.

The CHAIRMAN. Have you looked to the potential for offshore wind development near and around the State of Alaska? I recognize that the Scotland project is a big one for you but having been to Scotland and looking at their energy assets, I couldn't help but note many of the comparisons with my state.

Ms. KINDEM. Well, and I agree. I think it's—I think Alaska should be, could be relevant for us. We all know that in the report, I think it was from 2016 or 2017, restating the potential, more technical potential, but Alaska, then again there is, you know, there's some things that also challenging being far away to load centers, you know, being more remote areas. So you know, I wouldn't argue on that thing, but I will say, like a general view, that, you know, for us, we're looking at the U.S. in total. So the last thing could also be co-interest for us. And this is also, you know, climate wise, you know, as a climate we are used to working in.

The CHAIRMAN. One last question for you, Mr. Davies, and this is going to take it back to the Igiugig project there because this is not something that—you mentioned that it has been in the water now ten months and producing power for the community which, of course, is significant. But I had the opportunity, again, to go out there several years back, and it probably is more than several right now, and they had had the turbine in the river for a very brief period of time and took it out and recalibrated it and that went on for several, several summers. Of course, the seasonality of the project at that time just to determine how it was going to handle itself in winter conditions. Can you give just a quick recap on lessons learned there and what progress has been made since initial deployment?

I know that many in the state, and not just in our state but others, are going to look at this and say, well, we've got a river right out here. We will just do the same thing that they have done in Igiugig. We think, we recognize though that it is not the same in

every place and, in fact, it is unique in every place. Can you just speak a little bit to the lessons learned here?

Mr. DAVIES. Sure, thank you for the question.

So I think there's been a tremendous amount of learning over the last year. I mean, we've, and I think a lot of the news is great news. We survived temperatures as low as minus 40 degrees for a 15, 20 degree—15-, 20-day period. We—there was two feet of ice that broke up off of Lake Iliamna and floated over the top of the device. That was a very cold winter, and so I think it was a 10 or 15 high in terms of ice thickness. And so, all of those are tests that we wanted to see to, you know, we've designed that process that you talked about. From 2010 to 2016 was there were a lot of design changes in the components and how we designed the system to be able to withstand the harsh winter conditions in a remote community in Alaska because, you know, once you put it down in October, you really can't get access to it until next May. And so, we designed a number of components to be able to handle that, those winters.

In addition, we've really made a lot of advances in the way the device deploys and is retrieved and so it is now very modular. We can ship it in four containers, you know, standardized containers so, we're able to move it to a site very quickly and then, it's designed to work with the local resources of the community to put it in the water. So it can be assembled on the beach and pushed into the water with local equipment and then it takes very small capacity boats to be able to tow it out to the location and put on the device, put onsite. And then the pontoon structure we've designed to, the ability to basically, the pontoons fill with water and it lowers the, you push a button and it fills it with water and it lowers it down and then, you can push another button and it comes back up. And that's no small task for a device that weighs 30 tons.

And so all of that we've been able to test multiple times over the last ten months and you know, are happy to report we've had a lot of success on the device is back down on the river bottom and producing power today.

The CHAIRMAN. And not interfering with the fish?

Mr. DAVIES. Again, in our history, we've had a number of studies done and we've had no fish injuries or mortalities that have been recorded. You know, generally, if you think about where we're locating a device it's in the fastest flowing section of the river and fish migrating upstream are naturally going to disperse around that section of the river. Unfortunately, due to COVID we were not able to have Fish and Wildlife staff and people from the University of Alaska onsite to conduct fish studies, but we're hoping to do that next spring and the Department of Energy Water Technologies Office has extended our project deadline too and provided funding for us to do that next spring.

The CHAIRMAN. Okay, very good.

Well, Senator King, I just want to point out to you that this is yet another example of good, strong partnering between Alaska and Maine. This is, it has been really interesting to watch as this has really evolved over these years and I think, an opportunity for us.

Senator KING. Well, we are very proud of the work. We are very proud of the work that ORPC is doing. Although, now I noticed

your comparison of Alaska and Scotland. I urge that you not take up eating haggis though in Alaska.

[Laughter.]

There are limits.

The CHAIRMAN. I will take that under advisement. I appreciate that.

This has been a great discussion this morning, and I appreciate the conversation that Senator Cortez Masto brought up about the workforce and the imperative of the workforce here. I think it is important to note that our American Energy Innovation Act that Senator Manchin spoke to and that Mr. Lewis mentioned that we needed to pass expeditiously, does contain in it several workforce development pieces when it comes to our opportunities for some of these resources.

So a great exchange of information. I agree with you, Senator King, that it feels like where we are looking out toward the future and it is very exciting and there is a great deal that is going on. Thank you for sharing your updates with us this morning. We look forward to more progress in this area.

With that, the Committee stands adjourned.

[Whereupon, at 11:48 a.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

U.S. Senate Committee on Energy and Natural Resources
September 22, 2020 Hearing
An Examination of Emerging Offshore and Marine Energy Technologies in the United States, including Offshore Wind, Marine and Hydrokinetic Energy, and Alternative Fuels for Maritime Shipping
Questions for the Record Submitted to the Honorable Daniel R. Simmons

QUESTIONS FROM CHAIRMAN LISA MURKOWSKI

Q1. What partnerships does the Department have with NOAA for research into emerging offshore energy technologies such as MHK, offshore wind, and shipping fuels?

A1. The Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) has developed a strong partnership with National Oceanic and Atmospheric Administration (NOAA) in many of its offshore energy activities. The Water Power Technologies Office (WPTO) works with NOAA on designing marine energy systems to provide renewable, consistent power for ocean observing systems. Providing more energy to these systems without needing to recharge batteries on ships or at shore can dramatically reduce the cost of existing data collection efforts – for example, for mapping the U.S. Exclusive Economic Zone – and allow new types of data to be collected in new places. The partnership with NOAA is exemplified by the joint DOE-NOAA Ocean Observing prize, where we announced the winners of the first phase in April of this year. The second phase of the competition was crafted using a user-centric engineering design methodology informed by interviews and discussions with ocean scientists and engineers.

Additionally, NOAA has provided expert input to WPTO's exploratory effort to elucidate non-grid opportunities for marine energy (outlined in the Powering the Blue Economy report)[1]. In particular, subject matter expertise from NOAA was instrumental when considering ocean observation and aquaculture as potential markets to be powered by marine renewable energy. The Wind Energy Technologies Office (WETO) coordinates with NOAA on several important areas of offshore wind research and development, such as evaluating and mitigating the impacts of offshore wind on sensitive wildlife species and improving the understanding of offshore wind resources. This summer, EERE published a Request for Information in coordination with Bureau of Ocean Energy Management (BOEM), NOAA, and United States Fish & Wildlife Service (USFWS) regarding offshore wind environmental research priorities and is considering additional research efforts, working in partnership with these agencies, informed by those responses. WETO also has an Inter-Agency Agreement with

[1] https://www.energy.gov/eere/water/powering-blue-economy-exploring-opportunities-marine-renewable-energy-maritime-markets

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NOAA and the National Weather Service on wind resource science research, which is important for designing offshore wind plants, predicting their power output, and facilitating grid integration. High-fidelity wind data collected by EERE have resulted in improved forecasts, which NOAA has incorporated into widely used current operational weather forecast models. The agencies are now working together to improve forecast models for offshore wind that capture the strong interaction between the atmosphere and the ocean surface.

Q2. Many of these emerging offshore energy applications cut across multiple program offices at DOE, and many of these systems need to work together to realize their full potential. For example, your testimony mentioned three different offices within EERE that have potential shipping applications. How do you ensure that each of these program offices are able to collaborate on technology development when offices are focused on energy type rather than the final end use?

A2. DOE works collaboratively across offices as well as other Federal Agencies to ensure that research and development (R&D) activities are as holistic as possible, to leverage resources, and to coordinate efficiently while avoiding duplication in efforts. This interagency collaboration is of particular relevance to offshore and maritime technologies as they cut across multiple technologies as well as end-use applications. DOE offices ensure coordination through multiple mechanisms that cut across both technology and application focus. For instance, DOE performs R&D involving coordination across multiple offices on a variety of offshore technologies including: offshore renewables such as wind, wave, and tidal; seawater mineral extraction; offshore aquaculture; underwater vehicles; offshore hydrogen production, and ocean plastic remediation technologies to name but a few. Collaboration mechanisms include:

- The National Oceanographic Partnership Program (NOPP), which facilitates partnerships between federal agencies, academia, and industry to advance ocean science research and education. This group includes 16 different offices and agencies across the Federal enterprise interested in ocean science and technologies. This group has funded over 200 projects since its creation in 1997.

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- The Federal Renewable Energy Working Group (FROEWG) where offices across the Federal Enterprise meet regularly to share updates on federally funded projects and research related to ocean renewable energy.

Within the DOE, offices work together on a variety of offshore technologies from large multi-million dollar research initiatives to small research investments. These collaborations are created through many different avenues, from relationships among staff, to "Big Idea Summits" in EERE where staff specifically focus on cross-office concepts.

DOE also works on maritime energy R&D through a range of formal and informal workshops, joint project reviews, and other mechanisms such as:

- An Interagency Maritime Energy R&D Working Group, including DOE, United States Maritime Administration (MARAD), United States Coast Guard (USCG), Environmental Protection Agency (EPA), and the U.S. Navy. This group has been meeting for over a year and half and typically involves 40-70 federal employees, lab staff, researchers, and scientists to share updates on maritime energy related projects across the Federal government.
- The Transportation Research Board, which is part of the National Academies, includes specific activities to coordinate on maritime applications. DOE serves as an ex officio member of the Board and leadership regularly participates in its meetings.
- The U.S. Committee on the Marine Transportation System (CMTS), which is an interagency policy coordinating committee that assesses the adequacy of the marine transportation system and coordinates, improves collaboration, and makes recommendations with regard to Federal policies that impact the marine transportation system. The CMTS includes members from more than 25 Federal agencies and departments.

Examples related to shipping fuels include:

- Exploring biofuels for shipping as well as other fuels like hydrogen, liquefied natural gas (LNG), ammonia (includes collaboration with Office of Fossil Energy, the Advanced Research Projects–

Energy (ARPA-E), and others on LNG and advanced concepts for integrating technologies such as combustion and fuel cells for ship applications).

- While biofuel R&D has focused on vehicles in the past, increased emphasis includes aviation and heavy-duty applications including marine vessels.
- EERE is also leveraging its collaboration with USDRIVE and industry on developing net-zero carbon fuels (e.g., through hydrogen plus carbon dioxide to produce liquid fuels) to evaluate the opportunities for maritime use.
- EERE is collaborating with the USCG and Maritime Administration on developing codes and standards for hydrogen in maritime applications.

Q3. What work is being undertaken on hybrid energy systems where MHK or offshore wind work together with other energy sources?

A3. Hybrid and integrated energy systems hold significant promise, and are a priority of the Department. In August, the Secretary of Energy announced the launch of the Advanced Research on Integrated Energy Systems (ARIES) platform at National Renewable Energy Laboratory (NREL). ARIES is a cutting-edge research platform that will allow NREL researchers and the scientific community to address the fundamental challenges of integrated energy systems at scale. One example of such work is the demonstration of megawatt-scale hybrid energy systems (multiple renewable generation technologies plus storage) with active power controls to provide a full suite of grid services and support grid reliability.

Offshore generation technologies have the potential to be valuable elements of hybridized systems. For example, EERE's Wind Energy Technologies and Hydrogen and Fuel Cell Technologies Offices are working together to evaluate the potential of offshore wind to produce hydrogen as a long–term energy storage option, and for other applications, such as marine fuels.

Likewise, EERE's WPTO and the Office of Electricity are working together to evaluate tidal energy systems integrated with batteries. The recently launched partnership among the Energy Transitions Initiative, the Solar Energy Technologies Office, and Water Power Technology Offices that will

research how marine and solar energy systems may be integrated with other technologies as a means to provide energy to isolated community grids. EERE offices also work together to address cross-cutting barriers for offshore renewable energy, such as siting and the mitigation of environmental impacts.

Q4. What activities are you undertaking to establish partnerships with and among the various blue economy sectors you described in the powering the blue economy initiative?

A4. EERE's WPTO engages in a wide range of partnerships under the Powering the Blue Economy (PBE) initiative. These efforts are critical to ensuring marine energy technologies are developed with needs of end users front and center.

Across the federal government, EERE has partnered with a number of other agencies as part of PBE, including:

- The Department of Commerce's Economic Development Administration (EDA) to launch a joint Build to Scale Industry Challenge, which is enabling networks nationwide to provide entrepreneurial training and services to Blue Economy organizations;
- NOAA to administer the Powering the Blue Economy: Ocean Observing Prize and working closely to understand the power needs of ocean observers;
- The U.S. Navy to better understand their needs for new ways of powering ocean observing systems, including Autonomous/Unmanned Underwater Vehicles (AUVs/UUVs), and marine energy's potential to meet this demand;
- The Bureau of Reclamation's R&D division to understand desalination challenges and to review applications to the Waves to Water Prize, a prize aimed at developing portable, wave-powered desalination systems for deployment in remote communities and disaster relief scenarios; and
- The Department of Transportation's Maritime Administration to organize a series of inter-agency meetings on maritime energy R&D needs and helping coordinate and streamline collaboration.

In addition to the federal partners, WPTO, the NREL, and the Pacific Northwest National Laboratory continue to work with many non-governmental partners, research organizations, industries, and

communities from blue economy sectors who are likely to be the first customers for marine energy. A few of these partners include academic institutions such as the National Marine Renewable Energy Centers, marine energy testing sites, private companies in blue economy sectors (e.g., AUV/UUV, oil and gas companies), scientific consortiums, companies with deep expertise in materials, disaster relief organizations, and remote communities -- including island, coastal, tribal, and indigenous communities.

Q5. How is DOE partnering with specific communities that could most benefit from this new powering the blue economy initiative?

A5. Some of the earliest adopters of marine energy are likely to be remote coastal and island communities that rely on expensive fuel supplies with vulnerable supply chains. Recognizing these types of energy security and resilience issues, EERE's Powering the Blue Economy Initiative includes a specific focus on Remote Coastal Communities, driving technology to directly support applications where marine energy enables more resilient communities and local economic livelihoods. Applications such as microgrids, hybrid energy systems, energy-water services for disaster relief and small-scale supply, and nearshore economic applications such as seafood processing, tourism, and ecosystem conservation are all potential areas of technological innovation.

In addition to power for remote communities, offshore energy has the potential to generate a reliable source of freshwater. WPTO's Waves to Water prize supports the development of portable wave-powered desalination systems that are designed to be easily and quickly deployed in a remote coastal or island community in the aftermath of a natural disaster.

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QUESTIONS FROM RANKING MEMBER JOE MANCHIN III

Q1. The Federal Energy Management Agency (FEMA) recently announced a plan to award a $9.5 billion grant to the Puerto Rico Electric Power Authority to make improvements to their electrical grid and other infrastructure.

Q1a. Given its extensive work in Puerto Rico, to what degree is DOE involved in the planning and design of these improvements and repairs?

A1a. DOE is supporting FEMA under the National Disaster Recovery Framework Infrastructure Systems Recovery Support Function to develop technical capacity to ensure that funded recovery actions adhere to industry best practices and are coordinated with long-term capital improvement projects, future organizational and Commonwealth goals, as well as supporting the development of the next-generation energy sector workforce in Puerto Rico.

Following Hurricanes Irma and Maria, DOE undertook a multi-laboratory effort to support the rebuilding in partnership with its Argonne National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest, and Sandia National Laboratories. Phase 1, in Fiscal Year 2018, focused on energy modeling. In Phase 2, from October 2018 through December 2019, DOE and the national laboratories supported Puerto Rico stakeholders to make data-driven investment decisions, and plan and operate the electric power grid with greater resilience against future disruptions. Under an Inter-Agency Reimbursable Work Agreement (IRWA) executed with FEMA in April 2020, DOE and its Laboratories continue to provide technical support to ensure that obligated funds are used to accomplish the aforementioned goals.

Q1b. What is DOE's current plan to help PREPA and FEMA modernize the electric grid in Puerto Rico?

A1b. DOE continues to provide technical assistance to inform responsible public investments to ensure a reliable and resilient electric power system. To support this, in February 2020, DOE, in coordination with FEMA, Puerto Rico's Central Office for Recovery, Reconstruction, and Resilience (COR3), and the Puerto Rico Electric Power Authority (PREPA) established the Energy Technical Coordination Team (TCT). The TCT includes a diverse group of stakeholders, including Commonwealth representatives;

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FEMA leadership and program staff; subject matter experts from DOE, the Department of Transportation, and the Federal Communications Commission; the White House Puerto Rico Recovery Liaison; and other Federal, State and local partners and agencies. Through the TCT, recovery solutions and supporting financial resources available through the Federal family, nongovernmental organizations, and private sector will be identified in a unified and collaborative approach across the entire energy sector.

In addition, DOE will use the full network and expertise of the national laboratories to drive informed decision-making (such as resource forecasting), capacity building, and the use and implementation of next-generation technologies. This will help PREPA and the Puerto Rico Energy Bureau deliver least-cost solutions through the responsible use of public funds.

Q1c. How will DOE support the use of these funds to address the resilience of Puerto Rico's electric grid to future extreme weather events, earthquakes, and other natural disasters?

A1c. Resilience is embedded in all DOE support in Puerto Rico. The TCT will help inform and advance resilience solutions, from diversifying domestic generation to hardening the transmission and distribution system throughout the island. DOE's coordination with the national laboratories is also focused on grid resilience. To highlight an example, through funding from the IRWA, Sandia National Laboratories will work in key vulnerable communities to inform the design of microgrids, which may include renewable energy and storage, for critical services. Renewable, on-site energy and storage solutions can be valuable resources during extended electric grid outages.

DOE is also focused on technical assistance and capacity building for local stakeholders. This critical investment in human capital will enable local actors to make the most out of the FEMA infrastructure investments and ensure on-the-ground expertise to respond to future extreme weather events.

Q2. Over the past decade, many have highlighted the need for an offshore grid to help deploy offshore wind turbines along the East Coast.

Q2a. Do you view the current reality of individual projects developing their own transmission as a major barrier to the industry's expansion on the East Coast of the U.S.?

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A2a. No. Offshore wind developers have been proceeding with their plans and making the investments needed to bring projects to fruition, including planning for grid connection. Current U.S. offshore wind developers are primarily considering project-specific radial transmission interconnections, as those projects are relatively closer to shore with available interconnection points. However, as offshore wind scales up to compete for fewer interconnection resources from longer distances, it may be beneficial to consider other alternatives, such as how offshore wind integrates with other technologies.

Q2b. Is DOE undertaking any work to address or evaluate this issue? If so, please describe.

A2b. In 2014, EERE's Wind Energy Technologies Offices (WETO) completed the National Offshore Wind Energy Grid Interconnection Study,[2] which assessed the potential to overcome offshore wind barriers by reducing the cost of energy and reducing deployment times. Among other topics, this study took a high-level look at different transmission delivery configurations, both AC and DC, and radial (point to point from the wind farm to the landing point) versus networked (such as multiple wind farms utilizing common offshore transmission infrastructure through a "backbone" with one or more common landing points). WETO is currently assessing research gaps and needs in this area.

Q2c. What would be needed to reinvigorate a more efficient approach to developing offshore transmission infrastructure?

A2c. EERE's WETO is in the process of identifying research gaps and needs in several areas, including mid- to long-term offshore transmission assessments, generation and transmission adequacy and reliability assessments, onshore transmission congestion mitigation, and modeling and simulation needs for offshore wind studies.

[2] https://www.energy.gov/sites/prod/files/2014/08/f18/NOWEGIS%20Full%20Report.pdf

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QUESTIONS FROM SENATOR STEVE DAINES

Q1. Montana has an abundance of rivers, both big and small, that could host hydrokinetic energy technologies. Has DOE or other entities conducted a study of the potential MW output for Montana and the region? What economic impact would increased hydrokinetic energy have in Montana and the region?

A1. The Water Power Technologies Office (WPTO) has made publicly available assessments of the size of the resource potential for both hydrokinetic technologies and new hydropower development across the United States. According to Oak Ridge National Laboratory's New Stream-reach Development Resource Assessment,[3] there is still about 69 TWh/yr of untapped "new stream-reach" hydropower potential across the Upper and Lower Missouri River. According to a WPTO-funded study.[4] completed by EPRI, the Upper Missouri River has an estimated technically recoverable resource of approximately 2.8 TWh/yr. Though only a portion of these estimates translate to realistically developable resource potential in Montana, these estimates do suggest that Montana has some untapped hydropower and hydrokinetic resource potential. Greater detail on the specificity and location of these resources can be found in each of the reports. Additionally, at a more general level, WPTO is currently undertaking an effort to identify "alternative values" for small hydropower development that go beyond electrical generation. Small hydropower can also be built at existing non-power dams along with new technologies designed to move migratory fish into new habitats while minimizing individual or species-level impacts.

Q2. Outside of funding, what other tools does the administration have or need to increase use of in river hydrokinetic energy?

A2. EERE is focused on the early-stage R&D necessary to enable entrepreneurs and industry to develop and deploy novel technologies, such as in-river hydrokinetic energy systems. The results from EERE supported R&D projects will generate valuable data and knowledge that will inform business and regulatory decisions related to the development and deployment of in-river hydrokinetic energy systems.

[3] https://hydrosource.ornl.gov/node/22
[4] https://www.osti.gov/biblio/1092058

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QUESTION FROM SENATOR MAZIE K. HIRONO

Q1. Is the Office of Energy Efficiency and Renewable Energy (EERE) conducting research and development on the use of deep seawater for cooling and power (e.g., ocean thermal energy conversion), and if not, do you have a future research agenda in those areas?

A1. Marine and hydrokinetic (MHK) energy, as defined in the Energy Independence and Security Act of 2007, includes energy from differentials in ocean temperature (ocean thermal energy conversion or OTEC). The Water Power Technologies Office (WPTO) conducted research in OTEC in the early years of the MHK Program (2008 – 2012), including research in life-cycle cost analysis, cold water pipe technologies, and environmental impacts. In recent years, there has been a growing interest in OTEC applications for both grid and non-grid (blue economy) markets, in particular looking at underwater hydrothermal vents and potential for providing energy in deep sea and artic locations. OTEC technologies present a potential area for early-stage research for the U.S. Department of Energy and WPTO is evaluating opportunities to contribute to further developments in this space.

U.S. Senate Committee on Energy and Natural Resources
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An Examination of Emerging Offshore and Marine Energy Technologies in the United States, including Offshore Wind, Marine and Hydrokinetic Energy, and Alternative Fuels for Maritime Shipping
Questions for the Record Submitted to the Honorable Daniel R. Simmons

QUESTION FROM SENATOR CINDY HYDE-SMITH

Q1. If leases for either renewable or fossil projects are delayed or protested, that delays the ability to implement new technologies. How do you help the public understand the impact on either innovation or conservation funding each time a project is delayed or protested?

A1. EERE recognizes that the environmental and permitting process in the United States is complex, particularly when working with offshore technologies, and involves a variety of stakeholders, including other Federal and state agencies. EERE's primary focus remains on being a world leader in researching and developing domestic, clean, reliable energy choices in power generation and energy efficiency. DOE conducts research to better understand siting, environmental, and wildlife impacts of offshore renewable energy development, and where warranted, to design technologies and operational strategies to mitigate these impacts.

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QUESTIONS FROM SENATOR CATHERINE CORTEZ MASTO

Q1. Mr. Simmons, you noted in your testimony the role EERE has in overseeing the work of the National Labs.

It is my understanding that in 2018, your office expanded the list of topics that require "Tier 1" approval by your office before researchers at Labs, like National Renewable Energy Laboratory (NREL), can publish their findings – meaning that research conducted at our National Labs must be reviewed and receive sign off from political appointees, like yourself.

There are concerns that broadening the political influence on the research conducted by our National Labs could undermine their work on innovative technologies and cost-effective solutions to things, including grid modernization and transmission interconnection needs.

Q1a. Has the expanded "Tier 1" review process slowed down the release of relevant and important findings coming out of our National Labs?

Q1b. Can you list the topics that require this enhanced "Tier 1" review and shed some light on how this list of topics was developed?

Q1c. What number of studies have been reviewed and released since the "Tier 1" list was expanded? How many are currently awaiting review?

Q1d. Do you share concerns that this additional layer of review by the more political offices at the Department of Energy is politicizing and somewhat discrediting the work of our National Labs?

A1: The Department of Energy (DOE) is committed to the highest quality and integrity of studies funded by DOE programs and produced by the national laboratories and the Department itself. Through research supported by the Office of Energy Efficiency and Renewable Energy (EERE), hundreds of reports are published by the laboratories and EERE each year. DOE has always reviewed its program-funded research in order to ensure that the research meets quality standards, the requirements of the program that funded the research, cross-cutting elements are coordinated within and among programs, and that it complies with appropriate DOE rules and Office of Management and Budget regulations, which have constraints on research regarding budget impacts and legislative proposals, among others.

A tiered process has been in use by EERE since 2018 to ensure planning and review processes run smoothly and in compliance with the above. The highest tier, or tier one, includes items and subjects such

as congressionally mandated reports and outputs, grid reliability, new policy or regulation suggestions or recommendations, DOE-generated surveys and public opinion polls, potential overlap with Energy Information Administration models, and cost comparisons across energy sector technologies.

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QUESTIONS FROM SENATOR JOHN HOEVEN

Q1. North Dakota has abundant reserves of light-sweet crude oil, and we're working to make carbon capture technologies commercially viable, which will allow for more energy production with better environmental stewardship.

Your testimony mentions that global marine fuel consumption "is expected to double in the next 20 years" and that your office is exploring new fuel technologies for marine shipping, including biofuels and hydrogen.

Could you expand on some of the challenges and opportunities you have identified to better integrate the use of low-sulfur crude and biofuels for marine shipping, and how we can take advantage of this increased demand?

A1. Biofuels for marine shipping have the advantage of low sulfur content. The Bioenergy Technologies Office (BETO) is currently looking into the compatibility of biofuels and traditional marine fuels, like Heavy Fuel Oil (HFO) in order to blend and bunker together. For instance, renewable diesel can be blended with HFO to meet sulfur reduction regulations. The primary challenge faced by biofuels is that they are more expensive to produce than conventional very low sulfur fuel oil (VLSFO). In addition, renewable diesel is not currently available at large enough scale to allow commercial use by the shipping industry.

BETO is working with multiple national laboratories to determine how to reduce cost of production, develop alternative fuel pathways, and scale up innovative conversion technologies from pilot to demonstration and eventually commercial scale operation. Conversion processes such as gasification, catalyst fast pyrolysis, hydro-thermal liquefaction, and others have the potential to make renewable marine fuels that have similar characteristics to conventional HFO and VLSFO. The maritime and shipping industry is also under increasing pressure to reduce its CO2 emissions which will also impact the marine fuels market in the future.

In addition to the potential application of low-carbon fuels in this sector, DOE's Office of Fossil Energy is also investigating small-scale, modular systems, such as membrane technologies, that can potentially

capture the CO2 emissions from on-board fuel combustion. These emissions can be stored temporarily on-board and then subsequently utilized or permanently stored at a different location.

In addition, the marine industry is interested in exploring alcohols and other fuels that can be produced by biochemical routes. A wide variety of feedstocks can be used for these processes including biomass, sewage sludge, algae, and other industrial wastes. Passenger and freight vessel operators in and around major U.S. ports are experiencing increased pressures to reduce criteria pollutants in their operations. Helping to address this issue, DOE supports research to develop a range of biofuels and synthetic fuels, along with compatible utilization technologies and infrastructure for transportation end-uses such marine shipping. For example, hydrogen-powered coastal vessels, such as ferries and tugs are becoming attractive due to their zero air emissions advantage over diesel engine power. Hydrogen can power vessels directly (e.g., using fuel cells), and can also be used as a feedstock to produce synthetic fuels or biofuels that can power vessels using conventional combustion engines. The emissions footprint of these pathways is minimized when the hydrogen is produced through low-emission pathways, such as fossil resources with carbon capture, or renewable or nuclear energy sources coupled with water electrolysis. R&D through DOE's H2@Scale efforts are advancing the affordable production of clean hydrogen for diverse end uses, including synthetic fuels for maritime applications. Specific challenges related to infrastructure are discussed below.

Q2. If we were to utilize excess power capacity to produce hydrogen, which has the potential to be used as another fuel source, will that help keep some of our existing coal and nuclear baseload power generators connected to the grid by providing a new revenue stream?

A2. Hybrid energy systems integrating electrolyzers with baseload power such as nuclear or coal can provide value for diverse industrial and other end-use applications, including maritime shipping. The key is to get elecrolyzer costs down and increase utilization of the electrolyzer by coupling renewables with baseload power. This enables higher utilization of the electrolyzer so it is not operating only during intermittent solar or wind and therefore the levelized cost of hydrogen is reduced. High temperature electrolyzers can also use heat from nuclear and coal plants, in addition to electricity, to increase the efficiency of hydrogen production. EERE has been supporting electrolyzer technology R&D for over

two decades and has helped reduce stack costs 80% since 2002. We just launched the H2NEW consortium to bring national labs and industry together and further reduce cost. For example, today electrolyzer capital costs are as high as $1,500/kW at low volume. This results in a hydrogen cost of about $5 to $6/kg at $0.05 to $0.06/kWh electricity prices. Our goal is to get hydrogen production costs down to about $2/kg, for which we need $0.03/kWh electricity. We now have some first-of-a-kind projects under DOE's H2@Scale Initiative that are collaborating with industry stakeholders (such as Exelon and Xcel Energy) to explore these options with nuclear power and electrolyzers. A 1 GW nuclear power plant with a 70% capacity factor can produce more than 40,000 tonnes of hydrogen in a year during plant idle times (i.e., when not providing power to the grid). Leveraging nuclear-generated electricity and heat, hydrogen can be produced using low- or high-temperature electrolyzer technologies, and utilized onsite to service hydrogen needs of the nuclear plant (e.g., in turbine generator cooling), or exported/monetized in other end uses.

Q3. Are there infrastructure challenges that need to be addressed to transport these new fuel technologies like hydrogen to markets and ports along the coasts?

A3. Key infrastructure challenges include bulk storage of hydrogen onsite at ports, the development of associated codes and standards, and the cost and efficiency of hydrogen liquefaction. Liquid hydrogen is of particular interest at ports and other maritime applications given its high density relative to gaseous hydrogen. One challenge is that ports may not have the physical space to site hydrogen production or storage facilities. One current DOE project is developing a first-of-a kind water electrolyzer (for hydrogen production) on a moveable barge at a pier to refuel hydrogen marine vessels as a creative option for addressing this challenge. DOE is working with other agencies, including MARAD and DOT, to identify and address the main infrastructure challenges to wider-spread adoption of the hydrogen-based fuel options.

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Questions from Chairman Lisa Murkowski

Question 1: There is a strong need for additional offshore wind projects to receive their notices of intent (NOI) so they can begin development in earnest. Do you plan to begin issuing additional NOIs prior to the Vineyard Wind Record of Decision (ROD), or only afterwards?

Response: A timeline for issuance of NOIs to prepare Environmental Impact Statements (EISs) for additional offshore wind projects is undetermined at this time. In order to issue NOIs, BOEM must first complete several steps, including the establishment of cooperative relationships with other Federal agencies to ensure high quality documents are prepared. In addition, BOEM would have to determine that enough information has been provided by lessees in their construction and operations plans.

Question 2: Do you plan to begin permitting additional wind farms as soon as the Vineyard Wind ROD has been issued, or will you wait until that facility's construction is complete, if granted the final license?

Response: BOEM does not have a schedule for initiating the permitting process for additional offshore wind projects, other than for the South Fork project for which the NEPA process is underway.

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Questions from Ranking Member Joe Manchin III

Questions: Over the past decade, many have highlighted the need for an offshore grid to help deploy offshore wind turbines along the East Coast.

a. **Do you view the current reality of individual projects developing their own transmission as a major barrier to the industry's expansion on the East Coast of the U.S.?**

Response: Under BOEM's regulations, a lease for offshore wind development allows the issuance of one or more noncompetitive easements to shore for grid connection.

To date, COPs have proposed direct radial connection to the land-based grid. However, if a lessee wished to use an ocean grid, it could propose an easement to such a system as part of its COP, and BOEM would evaluate such an easement as part of the COP review.

For any proposed ocean transmission grid, BOEM would have to issue a right-of-way grant for use of the Outer Continental Shelf. Subsequently, BOEM would evaluate the proposal under a General Activities Plan and associated NEPA process.

The costs and benefits of a proposed ocean transmission grid would be highly dependent on the proposed project and its geographic location. These factors include the availability of grid interconnection and associated land-based upgrades needed.

b. **What would be needed to reinvigorate a more efficient approach to developing offshore transmission infrastructure?**

Response: Developing offshore transmission infrastructure will require close coordination and input from multiple stakeholder groups, including, among others, the coastal states, the wind industry, ocean users, utility companies and transmission regulators. While efficiency is an important factor, ensuring enough time is allocated to receive and evaluate stakeholders' views is a necessary part of the process.

Currently there does not appear to be a common solution among wind energy developers, coastal states, transmission developers, and transmission regulators. Identification of a common solution among these groups would provide greater clarity to BOEM on what course, if any, should be taken in the future.

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Questions from Senator Bill Cassidy

Question 1: Director Cruickshank, I've been told the President's announced 10-year moratorium in the South Atlantic, Eastern Gulf and Florida Straits available for energy leasing applies to offshore wind.

a. **Can you please confirm whether this is true?**

Response: The President announced the withdrawal of all energy leasing, including conventional and renewable energy, beginning on July 1, 2022. No new leases will be issued offshore North Carolina, South Carolina, Georgia and Florida, for a 10-year period beginning July 1, 2022.

b. **Because the moratorium in the South Atlantic does not begin until July 2022, if BOEM conducts a lease sale for offshore wind prior to that date, would a company still be able to develop the lease, or would that activity be prohibited under the President's order?**

Response: If a lease is issued by July 1, 2022, the proposed project would not be impacted. However, there are multiple stages remaining in BOEM's renewable energy leasing process that must occur before a lease could be issued.

Question 2: You state in your testimony BOEM is examining additional offshore wind planning activities in both the Atlantic and Pacific.

a. **When do you anticipate BOEM will schedule and announce the next offshore wind lease sale?**

Response: BOEM does not have a schedule for future offshore wind lease auctions.

BOEM is committed to working with all our stakeholders, including state and local governments, the fishing and maritime communities, and the offshore wind industry, to ensure potential development acknowledges and balances other ocean uses.

BOEM has begun planning activities to identify and assess potential wind energy areas in the Gulf of Maine, the New York Bight, California, Hawaii, and Oregon.

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Questions from Senator Martin Heinrich

Question 1: Future of Offshore Wind--It is clear that we need to accelerate the deployment of clean energy technologies to meet our 2050 climate goals. Offshore wind in particular is extremely well positioned to play a pivotal role in reducing greenhouse gas emissions. Yet, projects have struggled to get through the permitting process at BOEM. To date, we have no commercial-scale projects that have made it through the permitting process. There are various offshore wind projects that have submitted their Construction and Operations Plans (COPs), but most are waiting for BOEM to start the official permitting review process.

Does BOEM have a formal hold on issuing NOIs for offshore wind projects that have submitted their COPs?

Response: At this time, BOEM does not have a hold on or a schedule for initiating the permitting process for additional offshore wind projects. In order to issue NOIs, BOEM first needs to complete several steps, and establish cooperative relationships with other Federal agencies to ensure high quality documents are prepared. In addition, BOEM would have to determine that sufficient information has been provided by lessees in the COPs.

Question 2: When do you expect BOEM will issue Notices of Intent to start the official permitting review process for the numerous projects awaiting BOEM action?

Response: BOEM does not have a schedule for initiating the permitting process for additional offshore wind projects.

Question 3: Significant delays are likely if these pending offshore wind projects do not begin the official permitting review process at BOEM soon. Is Secretary Bernhardt aware of the substantial jobs and investments in manufacturing supply chain, US vessel construction and port infrastructure that are waiting on the sidelines because of the Department's lack of progress in permitting offshore wind projects?

Response: The Secretary recognizes the positive economic benefits associated with a new offshore wind industry. However, the Secretary wants to make sure any offshore wind projects are executed in a safe and environmentally sound manner that accounts for other important uses of the ocean. The Department's goal is to ensure that offshore wind projects, commercial fishing, and maritime navigation are all successful, and that there are no unexpected environmental consequences.

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Question 4: Vineyard Wind Project--The Vineyard Wind Project is still under review at BOEM. Is BOEM on schedule to issue the Final Environmental Impact Study in November 2020 and the Record of Decision in December?

Response: The application for this project was recently withdrawn.

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Questions from Senator Mazie K. Hirono

Question 1: The Bureau of Ocean Energy Management (BOEM) has jurisdiction for permitting and leasing of ocean waters for offshore wind. Can you describe if and how BOEM seeks public and community input in determining which sections of ocean space to lease and who to lease it to during BOEM's request for proposal (RFP) and selection processes?

Response: Prior to the issuance of a lease or grant, BOEM works to deconflict all areas to the greatest extent possible. To achieve this, BOEM conducts extensive stakeholder outreach, convenes regional and state renewable energy task forces, and requests information from industry and the public. In addition, any proposed projects undergo analysis through the NEPA process to identify and avoid, minimize, or mitigate potential environmental impacts.

To best facilitate these relationships and ensure effective communication from the very beginning of the planning process, BOEM created Intergovernmental Renewable Energy Task Forces.

These task forces are generally focused on a specific coastal region, which may be adjacent to one or more coastal states, and consist of members from the federal government as well as state, local and tribal governments. They provide a public forum for information exchange throughout BOEM's decision-making process – such as the development of public notices – and keep lines of communication open on important issues.

BOEM also issues a series of public notices during key points in the process. These notices announce potentially suitable areas for leasing and solicit public input, including from important ocean user groups. BOEM uses the comments and information submitted to identify areas of concern and to further refine the areas under consideration for leasing.

Public meetings are often arranged by BOEM at key points in our planning process to solicit input from stakeholders on specific topics, such as commercial fishing and maritime safety. In addition, BOEM will often attend meetings hosted by state and local governments, industry groups, and maritime user groups to provide updates and answer questions about ongoing planning activities.

Question 2: While there is significant potential for federal revenue from leasing areas for offshore wind development, there are also issues of environmental impacts, compatibility with fisheries and military missions, and availability of renewable power at affordable rates. In Hawaii, for example, electricity rates are among the highest in the country because of our geographic isolation in the middle of the Pacific Ocean. What other criteria besides lease price can BOEM factor into its selection processes for offshore wind projects?

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Response: When proposing an area for leasing, BOEM follows a process that includes all of the factors you mentioned in order to ensure the future success of all ocean industries and reduce the impacts from potential offshore wind development. This includes engaging stakeholders – including federal, state and local agencies, fishing communities, and the public – throughout our processes to highlight environmental as well as socio-economic considerations. BOEM continues to work with our state partners to identify potential leasing opportunities to assist states in meeting their offshore wind procurement goals. Aligning our leases with state goals helps provide certainty to the offshore wind industry.

Once an area is selected, the use of a multiple-factor auction format allows BOEM to consider both monetary and non-monetary factors in selecting a winner for offshore wind energy auctions. Using non-monetary factors in BOEM renewable energy auctions is currently authorized in 30 CFR 585.220 ("Multiple-factor bidding . . . factors may include, but are not limited to: technical merit, timeliness, financing and economics, environmental considerations, public benefits, compatibility with State and local needs, cash bonus, rental rate, and an operating fee rate." 30 CFR 585.220(a)(4)).

Question 3: What lessons has BOEM learned from the offshore wind projects in the Atlantic that it would apply to future projects in the Pacific? What are the unique challenges for development in the Pacific, and how does BOEM plan to address them?

Response: Developing good working relationships with our stakeholders has been instrumental in identifying potential areas for wind energy development.

We identify lease areas through a rigorous, multi-stage process that involves opportunities for significant public input. The areas we identify for offshore wind leasing consideration, which we call "Wind Energy Areas," appear to be best suited for commercial wind energy development with fewer environmental and user conflicts than other methods.

In addition, we have learned that open and frequent communication helps reduce user conflicts and establishes a strong foundation for future wind projects.

Finally, BOEM continues to work with the Department of Defense and the State of Hawaii to identify potential areas for future offshore wind development.

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Questions from Senator Cindy Hyde-Smith

Question 1: As we discuss the implementation of emerging offshore technologies, the challenge that remains is this: it is difficult to deploy technologies regardless of how green it might be without a reliable and functioning permitting and leasing program. What similarities have you seen between the challenges of leasing and permitting that an offshore wind development project might have as would a conventional oil and gas leasing project?

Response: For offshore conventional and renewable energy projects, BOEM must comply with the National Environmental Policy Act (NEPA) and other environmental laws prior to deciding whether to approve a plan. For offshore oil and gas leasing and exploration, development and production plans, BOEM prepares an environmental impact statement at the leasing stage, with the type of environmental analysis conducted at the plan stage varying based on geographic location and the nature of the potential impacts. For offshore renewable energy, BOEM typically prepares an environmental assessment for the lease sale, and the consideration of more site-specific potential impacts from development does not occur until after lease issuance, once a lessee submits a construction and operations plan. While several of the environmental issues and use conflicts are similar (e.g., noise from pile driving, and viewshed), these concerns vary by geographic region. Many of the lessons learned from leasing and permitting oil and gas can be applied to offshore renewable energy, such as identifying appropriate and effective mitigation and filling knowledge gaps through BOEM's Environmental Studies Program.

Question 2: Congress recently passed historic conservation legislation – the Great American Outdoors Act, which depends now almost entirely on federal royalties from offshore revenues to be successful. Could you draw a comparison between the typical offshore wind project vs an oil and gas development in terms of federal revenues and which one will likely produce more conservation revenues over the next 20 years?

Response: Leasing revenues received vary greatly between projects based on several factors. Wind and oil and gas leases both pay a bonus bid for rights to the acreage. All leases pay nominal per acre rental fees before operation or production. Renewable energy leases pay an operating fee and oil and gas leases pay a royalty once energy production begins. The operating fee and royalty payment revenues vary significantly based on the size of a project.

On average , considering bonus, rental, and operating fee/royalty revenues, we estimate that a medium size wind development (500 Megawatts (MW)) would generate approximately $110 million in leasing revenues over 32 years, whereas a large development (1,000 MW) would generate approximately $220 million over 32 years. A medium oil and gas development (25 million barrels of oil equivalent (MMBOE)) would generate $270 million in leasing revenues over 28 years and a large development (400 MMBOE) would generate $4.5 billion over 37 years. These revenue estimates are based on typical project sizes, recent bonus bids and projected energy prices for the U.S. Atlantic (wind projects) and the Gulf of Mexico (oil and gas projects).

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Questions from Chairman Lisa Murkowski

Question 1: Are marine and hydrokinetic technologies cost-competitive, taking into account other renewable energy technologies (solar, wind, etc.) as well as diesel fuel?

The answer to whether marine and hydrokinetic technologies are cost-competitive depends on the geographic location of the project. A solar project in a Sun Belt state or a wind project in the Midwest that are grid connected will offer far lower rates than marine hydrokinetics today, but we would expect that gap to close dramatically over the next ten years. Most remote communities in Alaska have marginal wind resources and have a four-month period with eight hours or less of daylight with a low sun angle, which make wind and solar impractical. Many of these communities must transport diesel fuel into their communities via airplane making diesel fuel-based systems very expensive. In these early adopter markets, marine and hydrokinetic technologies are very competitive or cheaper than the diesel alternative.

Question 2: There are many state-level incentive programs Qualified Energy Conservation Bonds, Renewable Portfolio Standards, and Public Benefit Funds available today for marine renewable energy projects. Is it too early to consider a dedicated federal Marine/Hydrokinetic energy (MHK) energy market incentive? Could such an incentive actually work to spur material progress in RD&D for MHK technologies?

The MHK industry has arrived at an inflection point. There are a number of companies with commercially viable technologies as well as a large number of communities that have expressed interest in adopting these technologies. However, these communities either lack the necessary capital to purchase MHK-based systems or, given current MHK system costs, are hesitant to make such a large investment without seeing more operating history on these devices or both. As a result, this is an ideal time to establish dedicated market incentives for MHK. Providing incentive funding as well as low-cost loans to communities that lack the necessary capital would enable these communities to not only adopt a renewable energy solution and reduce CO2 emissions, but to also significantly lower their energy costs providing the opportunity for economic growth from the savings. It would also provide MHK companies the opportunity to demonstrate the reliability of their systems, which would drive more rapid adoption of the technology and thus further reduce CO2 emissions.

Question 3: What are the best regions for further development of Marine/Hydrokinetic energy in Alaska?

Alaska is well positioned for statewide remote community microgrids powered by tidal or river hydrokinetic turbines. The best region in Alaska for utility-scale development of marine hydrokinetic energy is Cook Inlet, which has a tidal energy resource with the potential to power 100 percent of the Alaskan economy. This resource could provide a transformational renewable baseload power source for the future electrification of infrastructure.

Question 4: What opportunities are there in Puerto Rico or other Caribbean islands for developing MHK technologies?

A large number of Caribbean islands are forced to import diesel fuel to provide electricity costs, resulting in power costs that are four to six times those of the average American. While there are not strong tidal currents in the Caribbean, there may be many tidal channels that could potentially support an

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MHK-based microgrid. The Antilles Current (start of the Gulf Stream) touches Puerto Rico, and while the ocean gets very deep there, there might be some potential to deploy ORPC's devices. There could also be market potential to integrate or collocate our devices to existing hydropower facilities or other existing infrastructure. There may also be opportunities for other technologies in the MHK space—ocean thermal energy conversion (OTEC) or wave—that might be applicable.

Question from Senator Steve Daines

Question: In river hydrokinetic energy technologies have the potential to provide baseload, low impact, renewable energy throughout Montana. As you may know, Montana already has a robust traditional hydropower portfolio, providing over 40% of Montana's electricity generation. However, lengthy permitting delays and environmental lawsuits can discourage new hydropower facilities and put existing projects at risk. As we work to grow this emerging industry, what are some specific permitting and statutory changes that are needed from Congress to help get more hydrokinetic projects off the ground and into the water?

ORPC recommends the following adjustments to provide a more efficient permitting pathway for a large-scale commercialized permitting pathway:

- FERC to revisit the 2008 *Licensing Hydroelectric Pilot License Projects* whitepaper and revise guidance to better reflect the realities scale and impact of MHK devices to the environment
- FERC to revise Memorandums of understanding (MOUs) with state and federal agencies for more streamlined and timely coordination between agencies in the licensing process
- Congress to provide an exemption for MHK projects similar to that provided for qualifying conduits hydropower facilities, creating an accelerated licensing framework with FERC

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Questions for the Record Submitted to Ms. Siri Espedal Kindem

Questions from Chairman Lisa Murkowski

Question 1: What regulatory hurdles do you see inhibiting the growth of the offshore wind market?

We have two main suggestions to improve the regulatory process at BOEM-issuing Notices of Intent to prepare Environmental Impact Statements and working to develop an offshore leasing schedule. We urge the Department of the Interior to issue Notices of Intent to prepare Environmental Impact Statements (NOIs) for leased offshore wind projects. There are many projects in the queue awaiting BOEM's issuance to begin the environmental review and public comment period. By moving forward with NOIs, certainty will be provided not only to the developers, but the market will see forward progress leading to investments in the supply chain as well. Unlike the mature offshore oil and gas leasing program, there currently is no schedule for offshore wind auctions. Now that the offshore wind program is more mature, development has gained momentum and attracted significant capital. To continue the orderly and expeditious development of OCS wind resources, developers and other participants in the offshore wind sector need more certainty around future leasing. Consequently, we urge BOEM, working in consultation with state partners, to develop an offshore wind leasing schedule. Doing so will provide better information for planning and prioritizing investments, and it would be another step in demonstrating the Department's commitment to offshore wind.

Question 2: How could deployment of offshore wind affect our tourism industry?

In general, our projects are too great a distance offshore (16-20 miles) to impact the traditional coastal tourism industry. For communities looking to benefit from tourism related to the offshore wind industry, we've seen communities in the UK, for example at our Sheringham Shoal wind farm, establish visitors' centers and engage marine vessel owners for tours of wind farms.

Question 3: How much development of offshore wind can we reasonably expect beyond that mandated by State governments?

The potential of offshore wind is significant. The Department of Energy has indicated that US offshore wind has a technical resource potential of more than 2,000 GW of capacity. This is nearly double the nation's current electricity use. We have strong ambitions in the US and are encouraged by the continued demand for domestic renewable energy from the states. We are confident that as prices continue to decline and the industry grows, there will be additional demand for offshore wind power from various sources, as we've seen for other renewable generation, but I cannot comment on specific markets.

Question 4: What are the remaining areas of research and development are most promising to capitalize on the potential of offshore wind, floating offshore wind?

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For floating offshore wind research and technology development, our key objective is to further develop and improve methodology and software for design and operation of cost-competitive floating offshore wind turbines. This technology development is focused on substructures, mooring systems, and dynamic cables for floating offshore wind turbines as well as marine operations. We would welcome the opportunity to have ongoing dialogue and coordination with the Committee and DOE regarding DOE efforts towards offshore wind research and development.

Question 5: How could DOE accelerate the establishment of a US-based supply chain and American manufacturing investment for offshore wind?

In order to grow this industry, we need a US supply chain. DOE grants to support innovation in the supply chain, including supporting existing suppliers looking to retool facilities and deploy existing skills in this new industry, could help to ensure the supply chain will be ready to take advantage of the significant growth in this industry.

Question 6: The DOE wind program is currently the lowest funded R&D program within EERE. Does this funding level enable the wind program to achieve its highest and best use in ensuring U.S. leadership in offshore wind?

We support fully funding the R&D program with the EERE to help ensure the US continues to lead on offshore wind and is able to take full advantage of this burgeoning industry.

Questions from Ranking Member Joe Manchin III

Questions: Over the past decade, many have highlighted the need for an offshore grid to help deploy offshore wind turbines along the East Coast.

a. Do you view the current reality of individual projects developing their own transmission as a major barrier to the industry's expansion on the East Coast of the U.S.?

    a. There are significant interconnection challenges for offshore wind, with growing state procurements putting pressure on existing limitations to the onshore system's capabilities for handling injections of power. Going forward, it will be necessary to reinforce and reconsider the structure of the coastal onshore grid to increase resiliency and accommodate an increase in renewable power. While a coordinated approach by the states, RTOs, FERC and private developers toward onshore grid challenges is necessary, Equinor believes it is most effective for offshore wind developers to retain responsibility for offshore transmission facilities because of their experience managing infrastructure in a complex offshore environment.

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b. What would be needed to reinvigorate a more efficient approach to developing offshore transmission infrastructure?

a. There are many issues to consider in the development of offshore wind generation and transmission, including but not limited to the allocation of risk, development timelines and market considerations. Through extensive experience developing large, complex, offshore projects, offshore wind developers have gained the experience required for the construction of such infrastructure in a timely, efficient, cost-effective and safe manner. This standard system ensures that developers can bring the power generated at the power plant/project to market and is a crucial element of any generation project. Importantly, interconnection to the onshore grid will become increasingly challenging as additional offshore wind is developed. A holistic discussion about onshore grid requirements should be prioritized to ensure that offshore wind is not delayed due to grid constraints.

Questions from Senator Bill Cassidy

Question 1: What will be the relative cost per kilowatt hour for Equinor's deepwater floating offshore wind farm in Europe versus the relative cost for fixed bottom projects such as Beacon and Empire Wind?

We have seen a significant decline in the cost of offshore wind and expect that to continue. Floating wind technology is in an early phase compared with bottom fixed. Relatively few megawatts have been installed worldwide, and the supply chain is immature. This makes the current cost of floating offshore wind higher than bottom fixed. This is about to change, and we expect gigawatt projects in Asia and Europe within the next 5-10 years. We believe that our offshore experience from the North Sea and around the world makes us uniquely qualified to lead the way and further develop floating offshore wind. Indeed, most floating offshore wind designs originated in the oil and gas industry. Equinor currently owns, operates, and markets the output of numerous offshore wind facilities in operation, including the world's first floating offshore wind farm, Hywind Scotland. Currently, we are developing Hywind Tampen, the first floating wind farm in the North Sea and the world's first floating wind farm to power offshore oil and gas platforms. Hywind Tampen will also be the world's largest floating wind farm and it will be a test case for further development of floating wind, exploring the use of new and larger turbines, installation methods, simplified moorings, concrete substructures and integration between gas and wind power generation systems. We are seeing a cost reduction of 40% from Hywind Scotland to Hywind Tampen, and we believe floating wind will compete with bottom fixed prices/cost by the end of this decade.

Question 2: Ms. Kindem, the European market has a robust manufacturing presence to support offshore wind. However, I imagine there are some domestic sourcing requirements with neighboring states where Equinor owns its leases as well as capabilities in my state and along the Gulf Coast to support offshore wind activities.

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a. To what extent, do you envision European manufacturers supplying the components necessary to construct the turbines on Equinor's leases?

We will have a broad supply chain and look forward to leveraging and taking full advantage of opportunities in the gulf and look forward to having those discussions as our projects progress, and we are happy to stay in close coordination with your office. As a broad energy company with oil and gas operations in the Gulf of Mexico, we certainly can appreciate the knowledge and expertise of the industry in the region as well as the desire to support offshore wind.

Question from Senator Mazie K. Hirono

Question: What are the leading challenges and opportunities you see for developing offshore wind in Hawaii and the west coast of the United States?

Hawaii and California have very ambitious clean energy targets that will be extremely difficult, if not impossible, to meet without offshore wind. Moreover, offshore wind would provide numerous well-paying jobs and economic recovery for both states. However, Hawaii and California face similar challenges, including the lack of a supply chain, availability of ports and other infrastructure, significant water depths, and stakeholder concerns. Most immediately, the U.S. Navy has objected to offshore wind development in both locations due to conflicts with military operations.

In Hawaii's case, since much of the Navy's operations offshore southern Oahu are classified, negotiation and industry efforts to address concerns are especially challenging. In addition, while there are areas offshore Oahu that may be acceptable to the military (with certain restrictions), that acreage is problematic to other stakeholders due to cultural issues.

Offshore California's Central Coast, where there are population centers and existing transmission infrastructure, the Navy is concerned about offshore wind's impacts on training and readiness. Consequently, the Navy has been reluctant to identify enough sea space for commercial-scale offshore wind development. However, in a recent letter to Congressman Salud Carbajal (D-CA), who represents the Central Coast, Secretary of the Navy Kenneth Braithwaite expressed a willingness to identify a solution to offshore wind siting issues and offered his support to help resolve the matter to the satisfaction of all parties.

Equinor's view is that the development of offshore wind resources can be highly compatible with other uses of maritime resources and we believe that the Bureau of Ocean Energy Management (BOEM) should not preclude wind energy development at an early stage because of potential conflicting uses. Moreover, to prudently access the Pacific Ocean's vast resources in a compatible way, an open and substantive dialogue, coordination, and cooperation by multiple stakeholders, including the United States Military, is necessary. Therefore, Equinor

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encourages BOEM to continue its engagement with stakeholders in both states with the goal of designating multiple wind energy areas offshore Hawaii and California. This will enable developers to capture economies of scale and provide a lower cost of energy. It will allow for phased development, which may better fit available offtake solutions and could also be more suitable to local stakeholders. Finally, it will increase competition for offtake, providing an opportunity for developers to compete with one another on a power price. We believe there is an opportunity to move quickly toward lease sales in 2021 if there is the will to do so.

Question from Senator Angus S. King, Jr.

Question: Can you please elaborate and provide details about the impacts that Equinor's Hywind project has had on fisheries in the area?

During the planning phase for Hywind Scotland, considerations were given to the types of fishing that have been conducted both within the area that is occupied by the offshore windfarm, and the export cable route corridor. Hywind Scotland is unique when compared with conventional fixed bottom wind farms, in that we have power cables and mooring systems suspended in the water column, which of course make certain fishing techniques a challenge. The Hywind Scotland export cable is design such that it can be over-trawled; in doing so limiting the impact on fisheries, but also preventing impact to the operation of Hywind Scotland.

Equinor collaborated with a local consultancy company (Brown and May Marine Ltd.), so that we had direct links to local fisheries groups to provide information about the windfarm, and so that we could deal with concerns directly. Constant dialogue with the groups was maintained during the project planning, and installation phases to ensure that there was as little disruption as possible. During the construction phase, there were some minor impacts on local fisheries, with the requirement to remove/relocate equipment from the export cable route corridor. This was a short-term requirement to prevent any damage to equipment.

During the Operational Phase of Hywind Scotland, Equinor continue to maintain dialogue with local fisheries groups. We regularly present information about Hywind Scotland, specifically, any pertinent information gained from bathymetric surveys of the seabed. We have had to perform two surveys of the subsea equipment during the operations phase at Hywind Scotland; on both occasions we have maintained good dialogue with fisheries groups in the planning phase and had no impact during the execution of the survey.

It should be highlighted that Equinor has a project ongoing to review how we can better share the space occupied by an operational windfarm with other sea users. Hywind Scotland has been chosen as the pilot location for this project; we will trial the use of different fishing techniques, in collaboration with local fisheries, to ensure that fishing activities can be performed in within the area of the windfarm. This project applies the principles initially developed by the European Union from the 'Multi-use of European Seas (MUSES)' Project. We are happy to stay in touch with you regarding the outcome of this review project.

As we are with all of Equinors operational windfarms, at Hywind Scotland we are extremely mindful that we have to coexist with other sea users; a key part of this is continued dialogue and sharing of information.

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Questions from Chairman Lisa Murkowski

Question 1: How much more hydrogen infrastructure will the U.S. need to produce low-emission shipping fuels at scale?

The United States will likely need a significant amount of new hydrogen infrastructure to produce low- and zero-carbon shipping fuel at scale. We think the most competitive low- or zero-carbon shipping fuel will be ammonia, which is made by combining hydrogen and nitrogen. Powering 100% of *global* marine shipping would require roughly 500 million metric tons of ammonia annually, which is about a three-fold increase over the current annual global ammonia production level. If the United States increased its ammonia production by a factor of three (from 14 million metric tons currently to more than 40 million metric tons), that would involve a significant increase in production, transport, storage, and fueling infrastructure. But given the wealth of resources that the United States has for producing zero-carbon hydrogen and ammonia, the United States could increase its current production levels by much more than three times. That would come with a concomitant increase in infrastructure including new production facilities, pipelines, and storage tanks, and supporting infrastructure (zero-carbon electricity generation and carbon capture and sequestration infrastructure).

Question 2: The IEA predicts some maritime operators will transition to liquefied natural gas as its predominant fuel, due to its low cost, subsidies, and compliance with IMO's sulfur cap. How could this increased adoption spur (or at least not inhibit) the transition to zero-carbon fuels in the future?

There is a growing recognition within the marine sector that investments in LNG-fueled vessels are not consistent with science-based targets for mid-century decarbonization, and could thus become stranded assets. That recognition has led some engine manufacturers to work on the development of "future-proofed" dual-fuel engines that can burn ammonia and/or hydrocarbons (possibly including LNG). (*See, e.g.*, UMAS, *LNG as a marine fuel in the EU: Market, bunkering infrastructure investments and risks in the context of GHG reductions* (2018) (https://u-mas.co.uk/LinkClick.aspx?fileticket=yVGOF-ct68s%3D&portalid=0); DNV-GL, *Marine Forecast to 2050* (2020) (https://download.dnvgl.com/eto-2020-download).)

Question 3: In broad terms, what is the best estimate in your view of the cost of both R&D and follow-on commercialization for developing hydrogen-based shipping fuels?

According to a 2020 analysis by the Global Marine Forum (GMF), fully decarbonizing the global shipping sector over a 20-year period (2030 to 2050) by transitioning to hydrogen and ammonia fuels will cost between USD $1.4-1.9 trillion—or USD $70-95 billion on an annual basis. (By way of context, the annual investment in transitioning the shipping sector to hydrogen and ammonia fuel amounts to approximately 1/20th of the total annual global investment in energy (USD $1.85 trillion in 2018).) The bulk of the shipping sector transition investments (87%) would be for fuel production and land-based storage and bunkering infrastructure; GMF estimates that only 12% of the investment would go toward to propulsion systems and on-board fuel storage and another 1% would go to energy efficiency upgrades.

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Question 4: Are small nuclear reactors a potentially cost-competitive source of hydrogen? Are there recent studies analyzing this?

Nuclear power could be an important pathway for zero carbon hydrogen production. Advanced reactor design and construction developments that bring down the cost of nuclear energy, combined with less expensive hydrogen electrolysis systems, could make nuclear-based hydrogen production more competitive. Higher temperature reactors could be especially important in this space. The U.S. Department of Energy has supported the development of these technologies through the Hydrogen and Fuel Cell Technology Office and the Office of Nuclear Energy's Nuclear Hydrogen Initiative, but funding for work on nuclear-derived hydrogen should be increased.

A 2020 report by LucidCatalyst finds that "a new generation of advanced modular reactors, hereafter referred to as advanced heat sources, with new manufacturing-based delivery models, could deliver hydrogen on a large scale for $1.10/kg, with further cost reductions at scale reaching the target price of $0.90/kg by 2030." (LucidCatalyst, *Missing Link to a Livable Climate: How Hydrogen Enabled Synthetic Fuels Can Help Deliver the Paris Goals* (2020) (https://85583087-f90f-41ea-bc21-bf855ee12b35.filesusr.com/ugd/2fed7a_0b6f336cd110438fa77b7f127a64ffcb.pdf).)

Question 5: The IEA predicts biofuels to account for more than one-fifth of total energy use in shipping by 2060. Do you expect the supply of sustainable biomass to hinder the adoption of biofuels in the shipping industry?

Sustainability challenges are likely to hinder the wide adoption of biofuels in the shipping industry. The climate case for scaling up biofuel production—whether for marine shipping fuels or other uses—hinges in large part on the biomass feedstock that is used to make the biofuel. Some feedstocks—particularly waste products—can be used to make biofuels that offer clear greenhouse gas reduction advantages in a short amount of time; other feedstocks—including the crops that are used to make the vast majority of today's biofuel—do not offer clear benefits and can have a higher lifecycle carbon intensity than fossil fuels. There is a limited supply of the right kinds of biomass and they tend to be expensive to aggregate. Those supply challenges are compounded by a demand challenge: the aviation industry is probably prepared to outbid the marine shipping industry for whatever fuel is available. The marine sector would be better served by investments in hydrogen and especially ammonia, both of which are massively scalable.

Question 6: How will hydrogen's relatively lower energy density, impact the overall freight efficiency of cargo vessels?

Fuels like hydrogen and ammonia that have lower energy density than fossil fuels will generally require larger on-board fuel tanks, which could in turn impact maximum available cargo volume. Engineers at ship design and shipbuilding firms around the world are looking into ways to mitigate that issue.

Question 7: The shipping industry has the expertise to transport, store, and produce ammonia. What is the potential for ammonia to emerge as a commercially-available carbon-free shipping fuel? How could Congress support the development of this alternative shipping fuel?

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Based on our review of available literature and discussions with experts in the energy and marine industries, ammonia's commercial potential as a zero carbon fuel for shipping is significant. Several recent reports reached a similar conclusion, including the following:

- Lloyd's Register & UMAS, Techno-Economic Assessment of Zero-Carbon Fuels (2020) at 4 (https://www.lr.org/en/insights/global-marine-trends-2030/techno-economic-assessment-of-zero-carbon-fuels/).
- Alfa Laval, Hafnia, Haldor Topsoe, Vesta, Siemens Gamesa, Ammonfuel--An Industrial View of Ammonia as a Marine Fuel (2020) at 6 (https://hafniabw.com/wp-content/uploads/2020/08/Ammonfuel-Report-an-industrial-view-of-ammonia-as-a-marine-fuel.pdf).
- MAN Energy Solutions, Engineering the Future Two-Stroke Green-Ammonia Engine (2019) at 5 (https://www.man-es.com/docs/default-source/marine/tools/engineering-the-future-two-stroke-green-ammonia-engine.pdf?sfvrsn=2b4d9d8a_10).

There are some key steps that Congress can take to support the development of ammonia as a marine shipping fuel. In brief:

- The Senate should pass the American Energy Innovation Act of 2020.
- The Senate Energy and Natural Resources Committee should help reduce technology costs by further directing the Department of Energy to sponsor research, development, and deployment of ammonia reciprocating engines, high-temperature electrolysis, CCS-equipped gas reformation, and other critical technologies.
- The Senate Energy and Natural Resources Committee should direct additional federal support to zero carbon fuel production and end-use technology adoption through production and investment tax credits; through rebates and incentives for zero carbon fuel end-use technologies; and through tax credits for pipelines, terminals, storage tanks, and other infrastructure for zero carbon fuels.
- Congress should kick-start zero carbon fuels and marine shipping decarbonization through development loans and cost-share grants that facilitate the development of key zero carbon fuel production, transport, and end-use hubs across the United States.

Question 8: In your testimony you mention several demonstrations of hydrogen fuel cell-based ferries and near-shore transportation. What are the opportunities and the challenges for vessels powered by fuel cells and hydrogen fuel-cells over the longer term, and when do you think these technologies will be commercially available?

On-board hydrogen storage requires either deep refrigeration (to –423 degrees F (-253 degrees C)) to hold the fuel in a liquid state, or very high pressures (e.g., 10,000 psi) for storage as gas. Either approach creates challenges for vessels that need to carry enough fuel to travel across an ocean.

For ferries, tugs, and other near-shore applications, however, the case for hydrogen-powered fuel cells as a propulsion technology is more straightforward—especially in coastal regions with stringent air quality limits. According to the 2020 analysis by Lloyd's Register and UMAS (cited in the response to Question 7), the

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projected total cost of ownership for a bulk carrier powered by a hydrogen fuel cell is about twice that of a bulk carrier powered by an ammonia-fueled internal combustion engine. The economic case for hydrogen fuel cell-powered propulsion is likely to be significantly stronger for ferries and tugs. Because they typically operate on fixed near-shore routes, tugs and ferries can refuel more frequently than transoceanic vessels, thus mitigating the on-board fuel storage challenges posed by hydrogen's relatively low volumetric energy density.

Question from Senator John Hoeven

Question: You mention a need for "federal support" to help support the "infrastructure build-out" to support new fuel technologies, and in particular, connect inland "key production areas" with ports and other major demand centers.

In addition to certain tax incentives you mention to help move low-carbon fuels through new or "repurposed" pipelines, should Congress consider removing unnecessary burdens or permitting barriers to help better connect producers and consumers?

The Fixing America's Surface Transportation Act of 2015 (Pub. L. No. 114-94), known as the FAST Act, contains provisions for streamlining the processes by which federal agencies review and permit infrastructure projects. *See, e.g.*, Sec. 1311 (directing the lead federal agency to expeditiously develop a single document that consists of a final environmental impact statement and a record of decision, to the maximum extent practicable); Sec. 1312 (authorizing public entities involved in a project or program under federal review to provide funds to the reviewing agencies under certain conditions, "to support activities that directly and meaningfully contribute to expediting and improving permitting and review processes"). When these provisions are correctly implemented, the FAST Act could better help connect clean energy producers and consumers. By ensuring that the FAST Act is correctly implemented, Congress could expedite the review and potential approval of clean energy projects.