BLUE SKY MARITIME COALITION

www.bluesky-maritime.org

RESPONSE TO RFI FOR:
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Hydrogen Energy Earthshot

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1. INTRODUCTION

The Importance of Maritime

Hydrogen has a key role to play in decarbonization of the transportation sector and in particular the maritime sector. While there has been a great deal of attention paid to hydrogen's potential in road transport, there is a critical need for an Energy Earthshot in the Maritime sector to meet the challenge of decarbonization for vessels of all types and their associated shore-side infrastructure and activities that enable our critical waterborne value chain.

More than three percent of global carbon dioxide emissions can be attributed to ocean-going ships, and this is expected to grow to almost 20 percent if we do nothing in the maritime space and other sectors improve as anticipated. Maritime emissions today are comparable to major carbon-emitting countries—and the industry continues to grow rapidly. In fact, if global shipping were a country, it would be the sixth largest producer of greenhouse gas emissions[1].

Global collaborative efforts such as the Global Maritime Forum and Getting to Zero Coalition are tackling the deep-sea segment, which according to the IMO generates some 70 percent of the global maritime CO_2 emissions. In the US, the Blue Sky Maritime Coalition (see below) together with other groups is focusing on emissions from inland and coastal vessel including ports and terminals which are not addressed in the deep-sea segment.

Shipping is experiencing increasing pressure to decarbonize operations and to reduce emissions to air. Shipping's main challenge over the current decade is to accelerate a decarbonization pathway. Alternative carbon-neutral fuels, such as hydrogen, are an essential part of any pathway to achieving maritime decarbonization.

Increasingly, key stakeholders such as banks and cargo owners are focusing on decarbonization, and legislation was introduced at the end of the 116th Congress to reduce/eliminate vessel emissions from ocean transportation (H.R. 8632, Ocean-Based Climate Solutions Act). All this points to a changing business environment for shipping. It will shape the future fleet in important ways, particularly in the choice of fuels and

[1] *Shipping Impacts on Climate: A Source With Solutions*, July 2008, by Ellycia Harrould-Kolieb. https://www.cleanshipping.org/download/Oceana_Shipping_Report1.pdf

technologies. Decarbonization efforts will impact costs, asset values and earning capacity at an accelerating rate over time.

The Initial IMO GHG Strategy was established to reduce GHG emissions from international shipping by at least 50 percent by 2050 compared to 2008. In contrast to previous environmental requirements, meeting the IMO GHG reduction targets requires fundamentally more challenging technological and operational changes for shipping. The challenges include a transition to new and alternative zero-carbon/carbon-neutral fuels and unconventional technologies as well as different ways of working across all entities that are directly or indirectly involved in the shipping value chain, including ship owners, charterers and end-use customers of shipping cargos, port authorities, utilities, regulators, engine manufacturers, financiers and lending institutions, et al.

The decarbonization of shipping and additional forms of waterborne transportation are part of a global transition across all industries towards greater use of renewable energy and reduced reliance on fossil fuels. An increasing number of studies consider ways shipping could decarbonize, developing scenarios for the transition from conventional to zero-carbon or carbon-neutral fuels, along with technical and operational energy optimization. Hydrogen is a key fuel, or precursor for fuel production in all these scenarios. According to a report by DNV titled Heading for Hydrogen survey, 42 percent of senior oil and gas professionals investing in clean energy sources intend to invest more in hydrogen or develop hydrogen, and 40 percent of North American respondents agreed that hydrogen will be a significant part of the energy mix within 10 years. A separate American Bureau of Shipping (ABS) Pathways to Sustainable Shipping survey of shipowners and operators indicated that hydrogen was among the most attractive fuel options for the long term, with 60 percent of respondents stating they viewed hydrogen and ammonia as the most attractive fuel choices. Notably, the ABS survey also indicated that two thirds of shipowners currently have no decarbonization strategy in place. Both the DNV and ABS data show a clear trend towards hydrogen wherein the focus will be on producing low-carbon hydrogen, and more importantly, at scale[2].

In Shell's report, Decarbonising Shipping | Setting Shell's Course emissions reduction potential is described as follows:

[2] *Future Fuels in the Maritime Sector – Building the Bridge to Hydrogen (Part 3 of 10: Realizing a Hydrogen Economy Series)*; April 16, 2021; by Sean T. Pribyl, Julia M. Haines. https://www.hklaw.com/en/insights/publications/2021/04/future-fuels-in-the-maritime-sector-building-the-bridge-to-hydrogen

“Shell’s analysis of publicly available industry data suggests encouraging CO_2 intensity improvement in the global fleet between 2008 and 2018 – in the range of 20%-40%. The IMO’s Fourth Greenhouse Gas Study (2020) reports an industry improved carbon intensity of 30% on an energy efficiency operational indicator basis since 2008. This has been achieved by the introduction of larger ships; improved hull and onboard mechanical design; introduction of digital technologies that allow for better trim and improved management of operations such as ship speed and port scheduling; and the retirement of older less efficient vessels. If used more widely, existing energy efficiency technologies such as air lubrication, hydrodynamic optimization, wind technologies and improved hull coatings could further reduce emissions by up to 25% compared to today’s leading designs.”

The report goes on to say that “A key technology to unlock future marine fuels is the fuel cell. This technology could replace internal combustion engine technology, improve energy conversion, and lead to improved ship design with additional space for cargo. Moreover, fuel cells have the advantage of being able to work using a range of fuel types including LNG, hydrogen, or ammonia.”

“Shell modelling shows that a ship using a high efficiency LNG fuel cell and adopting other energy-efficient technologies could potentially reduce greenhouse gas emissions by up to 80% versus the 2008 baseline. Developing a green hydrogen or ammonia supply chain for marine fuel represents a viable path to zero emissions shipping.”

Vital contribution by the maritime sector to decarbonization

The U.S. domestic waterborne transportation industry will play a vital role in contributing to the rapid decarbonization of our economy. The maritime industry is the cleanest, least expensive, and most flexible option to deliver necessary transportation services and as such will be increasingly relied upon to meet a growing percentage of transportation demand.

For example, an authoritative report recently published by Princeton University, the Andlinger Center for Energy & the Environment, the High Meadows Institute, and Carbon Mitigation Initiative concluded that[3]:

- The volume of hydrogen required by 2050 in the decarbonization trajectories they studied amounts to between 0.8x to 2.2x of today's U.S. natural gas use (slide 222).
- The scale of CO_2 transport and storage by 2050 in their scenarios ranges from 1.3x to 2.4x current US oil production (slide 231).
- 280 million tonnes per annum of carbon sequestration capacity (about 16% of total sequestration capacity) is located near major coastal and inland marine transportation routes now served by the U.S. tug and barge fleet (slide 235).
- An investment of between $170 billion and $230 billion in pipeline capacity for CO_2 collection and transportation will be required by 2050. But the analysts apparently did not consider access to waterborne transportation options which could be available at lower cost (slide 245).
- The Biden administration has announced plans to install 30 gigawatts of offshore wind turbine generation capacity; installing and maintaining that capacity will require investment in net-zero vessels as well as related port and related infrastructure.

These projections suggest that the demand for waterborne transportation services could increase as the U.S. economy transitions to net-zero CO_2 emissions, even while traditional hydrocarbon trades decline.

Cross-sector innovation and collaboration is needed to develop effective solutions

Decarbonizing the maritime industry requires a multifaceted approach that includes vessels (the energy end-user), ports and utilities for the shoreside infrastructure (to deliver the energy that the ships will use), fuel providers (conventional and

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[3] *Net-Zero America: Potential Pathways, Infrastructure, and Impacts,* December 2020, by, from Princeton University: Eric Larson, Chris Greig, Jesse Jenkins, Erin Mayfield, Andrew Pascale, Chuan Zhang, Joshua Drossman, Robert Williams, Steve Pacala, and Robert Socolow, and from External collaborators: Ejeong Baik, Rich Birdsey, Rick Duke. Ryan Jones, Ben Haley, Emily Leslie, Keith Paustian, and Amy Swan. Princeton_NZA_Interim_Report_15_Dec_2020_FINAL.pdf

unconventional) and collaborative, cross-sector innovation between industry our research communities and the public sector to develop effective, safe and commercially viable solutions. We need to develop an environment that brings together all these key players to work in a systems-based approach to accelerate clean energy innovations needed for maritime emissions reductions. There are numerous examples of how collaborative regional (or cluster) organizations, coupled with government support, can make all the difference in bringing players together to work toward a common vision and implement maritime innovation projects.

The Blue Sky Maritime Coalition (the Coalition) was recently launched as a non-profit, strategic alliance formed to accelerate the transition of waterborne transportation in the United States and Canada toward net-zero greenhouse gas emissions. The Coalition brings together industry, community, government, academia and other stakeholders across the waterborne transportation value chain to pursue projects that remove barriers to accelerating development, encourage innovation, and promote policies in support of zero emissions.

Cross-functional collaboration will be utilized to enable swift mobilization and tangible, sustainable results. The Coalition was conceived and designed to bring together all parties that directly or indirectly play a part in the North American waterborne value chain, from cradle to grave, and to collaborative develop a roadmap to net-zero GHG emissions by 2050 by identifying barriers to decarbonization and then executing demonstration projects and other initiatives that help to remove those barriers.

The working model for the Blue Sky Maritime Coalition is to build membership from all companies and organizations that are directly or indirectly involved in maritime activities in the U.S. and Canada, and from that base build clusters of like-minded members to work on these demonstration projects. Membership includes organizations like Washington Maritime Blue, which brings together diverse players in Washington State across the quadruple helix of government, industry, research, and community organizations to address maritime decarbonization. They work to drive competitiveness and sustainability, turning decarbonization challenges into a competitive advantage and growth opportunities for their regional cluster. The Blue Sky Maritime Coalition acts to connect various cluster organizations and maritime industry participants in order to leverage learnings and solutions across all of North America, enabling our vision to think big, start small and scale fast.

While our official launch was just held on June 21, 2021, the list of current members is already well on its way in our mission of driving collaboration across the entire North

American waterborne value chain to eliminate maritime GHG emissions in the U.S. and Canada.

The list of current members includes the following:

The Blue Sky Maritime Coalition already has underway several foundational projects to create a framework to guide the decarbonization of the industry. These projects include:

- Estimating the carbon footprint of the maritime industry today, taking into account the diverse roles and capabilities of the U.S. flag fleet.
- Establishing standards for emissions reporting that will help to measure our progress to net zero.
- Creating a technology "roadmap" for the industry identifying critical technical developments necessary to meet our net-zero goal.
- Identifying modifications to existing charter and related vessel employment agreements to provide stronger and balanced incentives to reduce CO_2 emissions.
- Assessing innovative financing options, including carbon credits, that have the potential for creating tangible financial incentives for emissions-reducing investments.
- Participating in the policy-making process to inform the industry about possible developments at the federal and regional level and participating in public forums to communicate industry decarbonization priorities.

As we identify and prioritize demonstration projects to develop and test new solutions to decarbonization, the Blue Sky Maritime Coalition identifies a Project Manager to develop public-private funding and pull together a cluster of member organizations to execute the project and share the learnings. In terms of hydrogen opportunities, there are three projects currently under consideration:

(1) **Hydrogen Ferry and associated infrastructure**. This project would build on an ongoing joint industry project (JIP) led by Washington Maritime Blue to develop a battery electric Zero Emissions Fast Foil Ferry. This is a great collaboration example in the Washington State regional cluster that brings together three (3) ports, public utilities, private enterprises and federal government support from U.S. Department of Transportation, Federal Transit Administration, Accelerating Innovation in Mobility initiative. The Blue Sky Maritime Coalition is in talks with Washington Maritime Blue and other members across the U.S. and Canada to expand on this project in terms of technical scope by evaluating the feasibility and design modifications needed to move from battery to hydrogen fuel cells. The Blue Sky Maritime Coalition can also work to expand geographical scope, involving port authorities and ferry owners/operators in multiple East Coast, West Coast and Gulf Coast locations.

(2) **Hydrogen powered harbor tug and infrastructure**. In similar fashion to a hydrogen ferry project, this demonstration project would involve a “design once, build many” approach to proving the concept of a hydrogen-fueled tug vessel with necessary infrastructure in multiple ports across the U.S. For example, a similar project was recently announced by the California Energy Commission’s Notice of Proposed Award (NOPA) for Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM). This hydrogen tug feasibility study to be conducted for Southern California, could be replicated to other ports on the East Coast, West Coast and Gulf Coast. For this project, called “Hydrogen Zero Emissions Tug” or HyZET, the CEC is funding the design of a fuel cell-powered harbor work boat. Project partners include Crowley, Jensen, ABB, DNV, Chart, Port of Los Angeles, SoCal Gas, Southcoast AQMD, Ballard, and

CALSTART, which is leading the CEC grant award team. Details of the project are provided below[4]:

- 90-foot tug vessel, 6700HP electric drive
- 1.2MW fuel cell (6x Ballard FCwave) + 3.6MW ESS power
- Liquid hydrogen fuel storage and bunkering
- PoLA, PoLB operation
- One week of operation between fueling

Both of these projects aim to replace existing, aging vessels with zero emissions alternatives. These projects were selected, in part, because they could function from a single fueling location thus avoiding the complexity of developing a multi-port delivery mechanism. These two concepts are also aligned in a fundamental principle that drives the Blue Sky Maritime Coalition, which is that we cannot achieve decarbonization by making incremental improvements to today's practices, but rather we need to THINK BIG, working backwards from the vision of a decarbonized maritime value chain by 2050 to what needs to be done today, START SMALL as quickly as possible, and then SCALE FAST with what we learn. In the vein of connecting various clusters, the hydrogen tug project would start by building on the current hydrogen tug project concept that is envisioned in California as well as a similar project well underway in Europe. As the hydrogen infrastructure centers around ports, it is likely that the scope of the Hydrogen Tug project could well expand in some locations to shoreside port vehicles and activities as well as the local and regional trucking transportation sector.

(3) **Tacoma Green Hydrogen**. To demonstrate the potential of ports as hydrogen hubs, Washington Maritime Blue is leading development of a joint innovation project to utilize a 1 MW mobile fuel cell for shore power at berth for ships in Tacoma, WA. The fuel will be generated and stored by OCO, Inc. in the form of formic acid as a liquid hydrogen carrier, that can reduce cost and risk for the storage and movement of hydrogen. The electrolysis for fuel generation will utilize Tacoma Power's 97 percent carbon-free green energy primarily from hydropower, with interruptible load that leverage's their first in the nation electro-fuel tariff rate. The reforming technology for formic acid to be utilized in the

[4] *CHBC Briefing: Maritime*, California Hydrogen Business Council, April 27, 2021. https://www.californiahydrogen.org/wp-content/uploads/2018/04/20210427-CHBC-Briefing-Slides_reduced.pdf

hydrogen fuel cell is being developed by Pacific Northwest National Laboratory. This project brings together partners across research, private commercial, public utility and port organizations to demonstrate new technologies and the benefits of a systems-based approach to generation and use of hydrogen at scale. While several aspects of the research have received DOE and other federal funding, this project is still seeking funding to proceed with the mobile shore power demonstration.

(4) **While longer term, we are considering a submission in response to Department of Energy - Hydrogen Fuel Technologies Office 2021 H2@Scale CRADA Call Supporting Advanced Research on Integrated Energy Systems (ARIES)**. The submission proposes the development of a H2Grid, which will effectively optimize the use of renewable energy for powering the intracoastal marine vessels by converting green energy into green hydrogen. The H2Grid project will be used to: (1) test, develop, de-risk and deploy hydrogen powered, resilient shipboard power systems that can be used to reduce the emissions of this marine transportation sector significantly, even though traditionally it is perceived to be difficult to decarbonize; (2) This project will also look at establishing the hydrogen refueling infrastructure along the intracoastal Great Loop by utilizing the nearby renewable resources.

These types of collaborative demonstration efforts are key to advancing the maritime energy transition. But public funding that is structured to support such efforts is critically needed. Organization funding for operations is needed for these collaborations and cluster organizations as well as the project assets such as hydrogen vessels and shoreside infrastructure. This includes funding for planning, feasibility and demonstration phases. Project funding should be structured with multi-entity eligibility and participation, led by ports, shipping industry companies, or non-profit consortiums. This support is essential to enabling the organizations involved to have a level playing field commercially with current technologies to avoid first mover disadvantage.

Organizations like the Blue Sky Maritime Coalition and Washington Maritime Blue are leading the way in developing collaborative, cross-sector innovations to deliver effective maritime emission reduction solutions. But collaboration is needed with federal partners at the DOE and across agencies to deliver a carbon-free maritime industry.

The Energy Earthshot initiative for Hydrogen is a positive step forward in bringing the game-changing breakthroughs that will secure American leadership in enabling net-zero carbon technologies and support sustainable development around the world. We strongly encourage the DOE to consider a focus on maritime and port needs for growing the hydrogen opportunities for vessels and associated shoreside infrastructure to address the U.S. domestic fleet or shore-side emissions challenges that especially impact our near-port and disadvantaged communities. Given that the typical life of an international vessel is about 25 years versus 40 to 45 years for a U.S.-flagged vessel, the challenges to achieving decarbonization in the US may be even more daunting and need even more attention.

The Blue Sky Maritime Coalition believes that a collaborative, strategic approach between the public and private sectors in combination with all direct and indirect stakeholders along the maritime value chain in the U.S. is needed to create a roadmap for action to achieve decarbonization by 2050 across the entire U.S. waterborne transportation value chain. This approach will identify the barriers to success, prioritize these challenges against the balanced interests of environmental stewardship, economic and social interests, national defense and other critical success factors. From there, national goals for emissions reduction can be set with key milestones necessary to reach these goals by 2050. We cannot achieve success by making incremental improvements in a step wise fashion, but rather need to develop a strategic roadmap, involving the collaboration of all stakeholders, that works backwards from success in 2050 to identify the detailed actions that are urgently required today.

2. RFI SUBMITTAL

Using the proposed RFI structure for providing feedback on potential hydrogen demonstration projects the input from the Blue Sky Maritime Coalition's current activities is as follows:

Regional Hydrogen Production, Resources, and Infrastructure

1. Please describe specific ideal regions to support a hydrogen demonstration project which have the necessary resources available for clean hydrogen production and infrastructure, including, but not limited to water, renewables, nuclear, natural gas (with CCS) or other energy resources captured from waste streams (e.g., landfill, flare gas, wastewater treatment).

    a. How much hydrogen could be produced (in tonnes per day and per year) and from what resources? State the amount of each resource available, including water as required.

Comment
The potential for offshore wind energy to produce green hydrogen at scale is very promising, and work in this space is only just beginning. The Pacific Northwest region is ideal to support numerous hydrogen demonstration projects hosted at ports that can be scaled to other locations around the country. The abundant, affordable clean power and water resources available in Washington State provide an ideal opportunity for generation of green hydrogen. Recently passed state legislation such as the Low Carbon Fuel Standard, Cap and Invest, and the Clean Energy Transformation Act create the incentives and pathways that can help support the business case for hydrogen generation and use. The Washington Maritime Blue cluster organization has numerous Joint Innovation Projects and member organizations that can help advance shoreside opportunities for generation as well as shore power and vessel use cases. The Ports of Seattle, Tacoma and Northwest Seaport Alliance provide the linkages to cargo handling equipment and drayage truck operations for additional logistical and transportation opportunities for fuel cells. The proposed Tacoma Green Hydrogen project being led by Washington Maritime Blue could provide the opportunity to demonstrate how utilities can use their excess green energy production from seasonal hydropower and variable wind and solar power to produce hydrogen or other electro-fuels as liquid hydrogen carriers. OCO, Inc's formic acid technology allows hydrogen to be stored in the form of a liquid hydrogen carrier that is hydrogen dense, non-flammable, non-toxic, environmentally benign, can be stored in steel tanks and is easy to transport.

Together with the Blue Sky Maritime Coalition, the lessons learned and business cases can be applied to additional locations for further opportunities for demonstrations and scaling.

Currently, the State of New Jersey is leading development of offshore wind energy on the East Coast and is also well-positioned to play a key role in the advancement of hydrogen as a clean energy fuel. To date, the state has awarded contracts for over 3 GW of offshore wind electricity (with a commitment to deliver 7.5 GW by 2035) and is developing the first, purpose-built wind port on the East Coast. The NJ Windport is a transformative, hub-style marshalling port project that will serve offshore wind projects in New Jersey and up and down the U.S. East Coast.

On June 30, 2021, Atlantic Shores Offshore Wind, a 50-50 joint venture between Shell and EDF Renewables, was selected to provide 1.5 GW of offshore wind energy to the State of New Jersey. This project, located in a lease area approximately 10-20 miles off the coast of New Jersey between Atlantic City and Bearnegat Light, will generate power for more than 700,000 homes. The project is set to begin construction in 2024 and includes a number of key investments in New Jersey's top academic institutions including Rutgers University, Stockton University, and Rowan College. The project also includes an innovative 10 MW green hydrogen pilot with South Jersey Industries (SJI) that will test potential synergies for offshore wind to produce green hydrogen for a variety of potential uses aimed at accelerating energy transition and zero emissions applications.

b. Is there any existing hydrogen infrastructure or infrastructure that could be repurposed as part of a hydrogen demonstration? State specific location if available.

Comment
Hydrogen infrastructure around the U.S. is not yet integrated into a fully connected nationwide supply chain, but it does exist and is developing rapidly. Several large ports are located in areas where hydrogen production facilities are in operation, making it possible for future hydrogen-powered ships to obtain a ready source of hydrogen fuel. Of these port locations, the Houston Gulf Coast area is the most developed. Forty-six facilities in the larger Houston region produce hydrogen (1/3 of U.S. total production), and all are connected by 900 miles of hydrogen pipeline that link the ports of Freeport, Houston, Galveston, Beaumont, Port Arthur, Lake Charles, Baton Rouge, and New Orleans. Marine vessel refueling capabilities could be installed at any of these ports and leverage the existing pipeline and supply infrastructure. Further, the Houston area contains two (2) underground hydrogen cavern storage facilities with a capacity of over two million cubic meters.
Another example, as mentioned in the Introduction, is the potential ARIES submission on the development of a Hydrogen Grid (H2Grid) project along the East Coast, Gulf Coat and inland waterways to create a “loop” which will effectively optimize the use of renewable energy for powering the intracoastal marine vessels by converting green energy into green hydrogen. The H2Grid project will be used to: (1) test, develop, de-risk and deploy hydrogen powered, resilient shipboard power systems that can be used to reduce the emissions of this marine transportation sector significantly; and (2) This project will also look at establishing the hydrogen refueling infrastructure along the intracoastal Great Loop by utilizing the nearby renewable resources.

c. Is there large-scale hydrogen storage available such as geological storage, salt caverns, depleted oilfields, pipelines, or other appropriate options for hydrogen storage? If so, at what volumes?
d. Are there existing hydrogen refueling stations or liquefaction plants in the region, or plans underway for such infrastructure? If so, at what scale?

Comment
While hydrogen fueling stations are available at some locations in California, these are not typically installed at ports or terminals to support the maritime vessels, cargo handling equipment, drayage trucks and other logistical opportunities for utilizing hydrogen. Trucking of hydrogen to the demonstration sites can make the project costs prohibitive to implement. Vessel demonstrations cannot proceed without the fueling available and fueling infrastructure investments are not made until there is a sufficient queue of demand creating the chicken and egg dilemma as a barrier for more demonstration projects. We need funding opportunities that create and support the linkage of fueling infrastructure and end uses. More support is needed to help our ports, utilities, and maritime industry players install critical hydrogen fueling infrastructure at port locations for increased utilization.

e. Describe any environmental or ecological impact, both positive and negative (e.g., are there any wetlands, NEPA issues, environmental justice communities, other considerations).
f. Is the region a brownfield or greenfield site?
g. What siting concerns, if any, need to be addressed? Would any mitigation plans be required (e.g., flood plain or other siting challenges such as hydrogen coupled with offshore wind)?
h. Are there carbon capture and sequestration facilities that may be utilized in the vicinity and what scale of hydrogen production and CO_2 storage could be achieved?
i. Are there any other considerations in the region for large-scale hydrogen production?
j. What are the demographics of the area immediately

surrounding the site, including racial demographics and socio-economic characteristics?

k. What are the characteristics of the area immediately surrounding the site (e.g., residential, industrial, rural, urban)?

Comment
All of the questions above would be investigated as part of the Hydrogen Tug, Hydrogen Ferry and other similar demonstration projects mentioned in the Introduction of this document. While project locations are not yet known, these will center around ports which in general are in industrial areas surrounded by lower socio-economic residential communities. These communities would greatly benefit from the lower emissions as a direct outcome of these projects. Also, as the Coalition grows in membership we expect to add additional fuel provider companies that will expand the diversity of thought in these answers.

End Users for Hydrogen in the Region and Value Proposition

2. Please describe existing and potential future end users for the hydrogen in the region, such as industrial, transportation, chemicals manufacturing, heavy-duty trucks, and other end uses.
   a. Distinguish between existing and potential future end users and specify anticipated time frame.

Comment
The powered fleet in the US waterborne transportation industry consists of nearly 10,000 vessels, the great bulk of which are tugs providing harbor, coastal or inland waterway transportation and related services. Although the vessels may have a 40-year useful life, engine renewal is a common strategy in response to regulatory or financial incentives. It is likely that all of the nearly 10,000 existing powerplants will be replaced by 2050.

b. Specify the amount of hydrogen currently needed and potential future needs (tonnes per day and per year).
c. Specify the proposed distribution network and geographical footprint required to reach end users.

Comment
Fuel distribution to the domestic waterborne transportation is dominated by fueling capacity in leading ports and terminals on the US coast and inland waterways.

d. Are there any commitments already in place for off-takers or by when could there be commitments?

Comment
There are several demonstration projects underway on the West Coast that will utilize hydrogen-powered tugs and ferries.

e. If using existing transport infrastructure are there limitations to the amount of hydrogen that can be blended into these systems and/or will there be modifications to these systems necessary to carry hydrogen?

Comment
Existing infrastructure is dedicated to supplying diesel oil; it is anticipated that new infrastructure development will be required to fully exploit hydrogen options.
The U.S. Energy Information Administration (EIA) estimates that in 2019, diesel (distillate) fuel consumption in the U.S. transportation sector resulted in the emission of 456 million metric tons of carbon dioxide (CO_2). This amount was equal to about 24 percent of total U.S. transportation sector CO_2 emissions and equal to nearly nine percent of total U.S. energy-related CO_2 emissions in 2019.

The Blue Sky Maritime Coalition is in the process of preparing a CO_2 inventory for the U.S. Waterborne Transportation industry. Our preliminary estimates suggest that the highly efficient waterborne transportation system accounts for less than 10 percent of those emissions. However, it is important to keep in mind that policies establishing incentives for reducing CO_2 emissions, like a carbon tax, would likely shift cargo from relatively high emissions transportation modes (like trucks) to relatively low emissions modes (like tugs and barges). The waterborne transportation industry thus may have a disproportionate potential for national CO_2 emissions reduction.

3. Please describe the business case, including the return on investment and timeframe.

    a. Include the costs for all stages of hydrogen use, including production, storage, delivery, infrastructure, and end use.
    b. What are the anticipated capital and operational costs?
    c. What local or regional policies or regulations, if available, would support the business case?
    d. Describe how the project is supported by or consistent with local or regional industrial cluster trends or initiatives.
    e. Describe, with specificity, anticipated economic opportunities for minority communities and/or underserved populations in the region.
    f. If already planned or available, describe financing mechanisms to be utilized or any other approaches.

Comment
The transition to hydrogen (or any new fuel) has four components: 1. A commitment from a shipper for long-term employment of the new technology vessel.

2. An owner with the capacity and resources to successfully deploy the new technology in the demanding maritime environment.
3. A banker who can translate the long-term charter into debt capacity and funding to support the necessary investment.
4. A public or private partner who is prepared to help mitigate the first mover disadvantage.

As it was with solar cells and wind power, the key to financial success of any energy innovation is to achieve scale and the cost reductions that scale supports. The first mover disadvantage is very simple: they are starting at the top of the cost curve and, when the innovation succeeds in getting to scale, they will be competing with much lower cost alternatives.

This formula for success is by now well-known and it is clear that there is no shortage of capital when the right terms are in place. The Blue Sky Maritime Coalition membership includes representatives of leading shippers, owners, and lenders who will play a role in the energy transition and is in close touch, through its policy workstream, with policy makers to address the first mover challenge. We are focused on taking practical steps to address all these critical success factors.

4. <u>What is the potential benefit to utilizing hydrogen to enable grid resiliency?</u>

   a. Are there opportunities for hydrogen storage as backup power for the energy grid in case of power outages?
   b. What are the challenges with storing and production of hydrogen from the project at scale to support grid resiliency?
   c. Are there opportunities to utilize hydrogen power to ensure cybersecurity?

Comment
As described in Question 1 above, there is certainly the opportunity to produce Hydrogen as a way to store excess energy from other

green sources such as wind, solar and hydro, during periods of excess production. The Blue Sky Maritime Coalition will touch on this as part of maritime infrastructure needs and will also explore ways to share storage and grid development that touches other sectoral needs as well (such as trucking transport and community needs near maritime ports). Details would follow on from specific projects in the future. A large percentage of utility plants and all of the new offshore wind farms are located in marine environments. Historically many of these locations used waterways as both a source of cooling water and as the delivery vector for fuel (coal, oil) and as such have some of the key elements such as, robust connections to the grid, docks, acreage for legacy fuel storage systems, and navigable waterways, which would be needed for a future marine-based distribution center. These would make water-based utility brownfield sites high potential for future hydrogen electrolyzers.

Greenhouse Gas (GHG) and Pollutant Emissions Reduction Potential

5. Please quantify the amount of emissions reduction anticipated and in what timeframe.

    a. What is the carbon dioxide emissions reduction potential (in tonnes per year) from cradle to plant gate and in what time frame?
    b. For complete pathway (production, delivery, storage, end use), specify total GHG reduction potential if available. Also, specify the boundary conditions for the life cycle emissions (upstream, within production plant gate, and downstream for end use).
    c. If there is potential for other emissions reduction (e.g., NOx, SOx, particulates), please specify anticipated amounts and in what time frame, as well as anticipated beneficiaries of the reductions.
    d. If there are caveats such as availability of CCUS facilities, please provide details.
    e. If there are offsets such as reforestation, renewable energy credits, etc. that may be provided as part of the project(s) in a region, please specify.

Comment
As noted above, the highly efficient maritime transportation industry likely accounts for less than 10 percent, or 40 million tonnes/year of CO_2 emissions in the United States. Replacing the 10,000 powerplants now in existence in the fleet with electric- or hydrogen-powered options will require 30 years. The industry has invested heavily in engines that meet the highest standards for NOx emissions. As noted above, CCUS will be a significant driver of demand for waterborne transportation services. It is unlikely that CCUS will play at role at the vessel level for the tug and towboat fleet.

Diversity, Equity, Inclusion (DEI), Jobs, and Environmental Justice

6. Please describe any additional opportunities for DEI, as well as environmental justice and the potential to positively impact underserved communities.

   a. Describe community stakeholder engagement opportunities.
   b. Describe opportunities to improve historically underserved communities.
   c. State whether the region is a considered a distressed community. Would the project(s) be on tribal land?
   d. Describe environmental and ecological impacts of land use, resources use, and disposal/emission/recycling of process waste and equipment at end of life.

Comment
Blue Sky Maritime Coalition project locations will center around ports which in general are in industrial areas surrounded by lower socio-economic residential communities. These communities would greatly benefit from the lower emissions as a direct outcome

of these projects. These could also be framed to provide educational and employment opportunities in these communities.

7. Please specify the job opportunities in the region that would be available because of the proposed project(s).

   a. Indicate gross versus net jobs.
   b. Indicate the sustainability of the jobs.
   c. Indicate the number of jobs required for installation versus subsequent maintenance, manufacturing, or other ongoing service jobs in the region.
   d. Indicate any opportunity zones in the region, including tribal lands, Historically Black Colleges and Universities (HBCUs), or other minority serving institutions.

Comment
According to a study commissioned by the American Waterway Operators (AWO), in 2014 the U.S. tugboat, towboat, and barge industry generated revenues of $13.6 billion, *directly* employed 38,660 workers, and paid out $3.9 billion in compensation (including wages and salaries and benefits), an average of $101,586 per worker. The industry also contributed $7.9 billion to U.S. gross domestic product (GDP) and invested $940 million in property, plant, and equipment, including its purchases of vessels.[5] In addition to 38,660 direct jobs, the U.S. tugboat, towboat, and barge industry supported another 244,900 *indirect* and *induced* jobs in other sectors of the economy, more than 6.0 additional jobs for each direct job in the industry.

[5] *Economic Contribution of the US Tugboat, Towboat, and Barge Industry,* Prepared by PWC for the American Waterways Operators, December 2, 2016.

Combining both operational and capital investment impacts, the U.S. tugboat, towboat, and barge industry directly or indirectly supported 283,560 jobs in 2014. Counting direct, indirect, and induced impacts, the U.S. tugboat, towboat, and barge industry's total impact on labor income (including proprietors' income) was $18.3 billion. The industry's total impact on U.S. GDP was $32.1 billion in 2014.

Nationwide, the U.S. tugboat, towboat, and barge industry directly paid or collected more than $1.0 billion in federal, state, and local taxes in 2014, including corporate income taxes, excise and sales taxes, and other taxes borne or collected by businesses. The industry indirectly supported an additional $2.2 billion in taxes borne and collected by suppliers. Including direct, indirect, and induced tax impacts, the U.S. tugboat, towboat, and barge industry had a combined tax impact of more than $4.9 billion in 2014.

The Blue Sky Maritime Coalition does not currently have comparably detailed information available for the ferry and offshore markets. A rough estimate of the total economic impact of the U.S. waterborne transportation industry can be derived by comparing the total number of other powered vessels engaged in the business with the tug and towboat fleet. The other powered vessels are, in total approximately equal to 50 percent of the tug and towboat fleet.

Using this rough adjustment factor, the total number of direct jobs could amount to almost 60,000 and indirect and induced employment to 375,000. Proportionately adjusting for income and taxes, waterborne logistics labor income could amount to $27 billion and $48 billion in terms of impact on GDP. The combined, proportionately adjusted tax impact is about $7 billion.

State-Level Economic Contributions
The industry was active in 38 states in 2014 but had an impact on the economies of all 50 states plus the District of Columbia through its indirect and induced economic impacts.

Ranked by direct jobs in 2014, the industry is largest in Louisiana, Texas, Kentucky, Tennessee, and New York (see figure 1 below). These five states accounted for nearly 63 percent of all direct employment in the U.S. tugboat, towboat, and barge industry. The industry's total impact by state varies based on the level of direct activity and the share of the industry's supply chain in each state. In 2014, the total number of jobs *directly or indirectly* attributable to the U.S. tugboat, towboat, and barge industry were highest in Louisiana, Texas, Kentucky, California, and New York. Combined these five states accounted for nearly 48 percent of all jobs and more than 50 percent of all GDP attributable to the US tugboat, towboat, and barge industry.

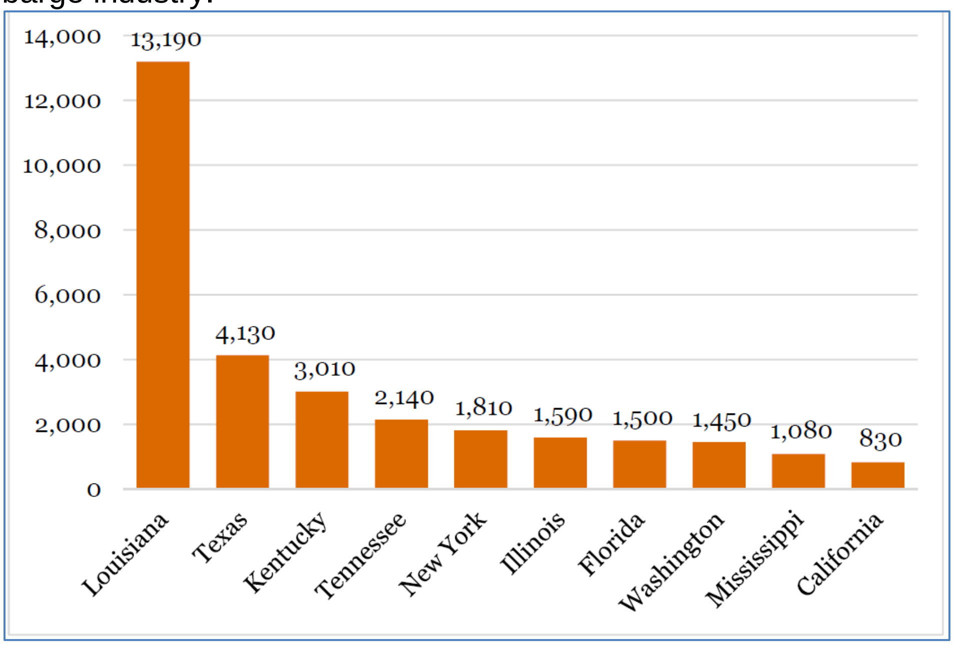

Figure 1. Employment by State in the tugboat, towboat, and barge industry

It is noteworthy that Louisiana alone has 150 Opportunity Zones as certified by the U.S. Treasury.[6] Louisiana is also home to six

[6] A map of these zones appears at: Louisiana Opportunity Zones (arcgis.com)

Historically Black Colleges and Universities (Dillard University, Grambling State University, Southern University at New Orleans, Southern University at Shreveport, Southern University and A&M College, and Xavier University of Louisiana).[7] There are a total of 35 Historically Black Colleges and Universities in the states shown in figure 1.

8. In regard to environmental justice communities/neighborhoods that could make better use of minority serving institutions, or could benefit DEI/underrepresented groups (URG) through internships or training opportunities, please identify:

    a. Any challenges or barriers that need to be addressed.
    b. Any opportunities or innovations that could be implemented that are relevant to advancing hydrogen technologies in these communities/regions for positive impact.

Comment
When it comes to diversity, equity and inclusion in the maritime sector, we have a lot of work to do to bring greater sustainability to the maritime workforce. This is true for race, gender, and even age. According to the International Maritime Organization, women represent just two percent of the world's 1.2 million seafarers. Also, the industry is facing a "silver tsunami" with an aging workforce that needs to be backfilled. The emissions impact of port and maritime operations are often increased for our near-shore communities. When Washington Maritime Blue developed the state's strategy for the Blue Economy, it included a report on "Workforce Sustainability in Washington's Maritime Industry[8]". According to publicly available employment data, most maritime subsectors are not representative of the state of Washington in terms of gender, while some

[7] See: List of historically black colleges and universities - Wikipedia

[8] Washington's Strategy for a Blue Economy: Charting a Course to 2050 (Appendix C: Whitepaper – Workforce Sustainability in the Washington Maritime Industry), January 2019, by Tressa Arbow. https://maritimeblue.org/strategy

subsectors are more representative of certain races in comparison to Washington. While the employment statistics available for Washington State confirmed that the majority of maritime workers are white, perhaps more importantly, the lack of publicly available employment data, distinct NAICS codes, or other mechanisms of examining the maritime workforce illustrate the need for more comprehensive data on demographic variables. Without a clear understanding of who is employed in maritime, it will undoubtedly be difficult for decision-makers to know how and where to support workforce sustainability initiatives.

The report highlights three themes that emerged from key interviews and conversations with players in this space:

- The Washington maritime industry needs a recognizable story
- Entry barriers prevent equitable access to the industry
- Internal dynamics of maritime culture impact retention of a diverse workforce

To address some of these challenges, the Youth Maritime Collaborative, hosted by Washington Maritime Blue, is providing internships with a focus on youth and communities of color. The program also provides equity training for the companies hosting the interns.

Youth Maritime Collaborative is comprised of members from the Port of Seattle, regional maritime organizations, youth programs, industry leaders, education programs and local government agencies. As a team, the Collaborative works to create career pathways for youth pursuing careers in the maritime industry.

Maritime Blue is committed to guiding today's youth toward maritime-related careers. With a focus on reaching underrepresented communities through experiential events and high school internships, the Youth Maritime Collaborative works to connect companies with the next generation of workers.

The Blue Sky Maritime Coalition plans to continue its collaboration with other industry organizations to expand these opportunities nationally.

Science and Innovation Needs and Challenges

9. Please provide input on any fundamental science, basic or applied research, and innovation needs and challenges that may be required for, or be informed by, the demonstration projects. In addition, please identify scientific user facilities or computational tools that would provide the required innovations or resolve the remaining challenges.

Comment
The material below is excerpted from a potential submission in response to Department of Energy - Hydrogen Fuel Technologies Office 2021 H2@Scale CRADA Call Supporting Advanced Research on Integrated Energy Systems (ARIES). The submission proposes the development of a H2Grid. NREL ARIES offers a high-fidelity, real-time, configurable emulation environment where existing and future energy systems and controller technologies for integrating novel systems can be prototyped, developed, and de-risked. Using its large constellation of digital real-time simulators, digital twins of large power systems, hardware-in-loop capabilities to test actual devices, and "control-at-the speed of communication" - integration of hydrogen-powered H2Grid with the evolving infrastructure of future shipboard power systems can be emulated and analyzed at-scale of up to 20MW for multi-physics analysis of system interactions such as mechanical to electrical, electrical to molecule (hydrogen, liquid air, ammonia). Using a digital multiplier at the digital real-time simulation facility at ARIES, the analytics can be scaled 20 times (20x) of the base capacity while taking the physics and all systemic non-linearities into account.

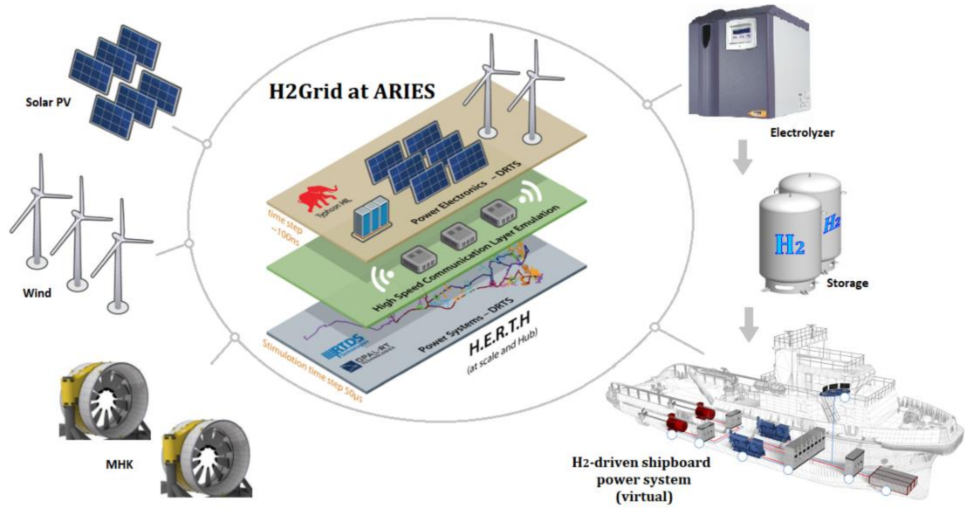

Figure 2. Emulation of H_2 fueling infrastructure for intracoastal marine applications utilizing ARIES' actual PV, Wind, and Electrolyzer as hardware-in-the-loop.

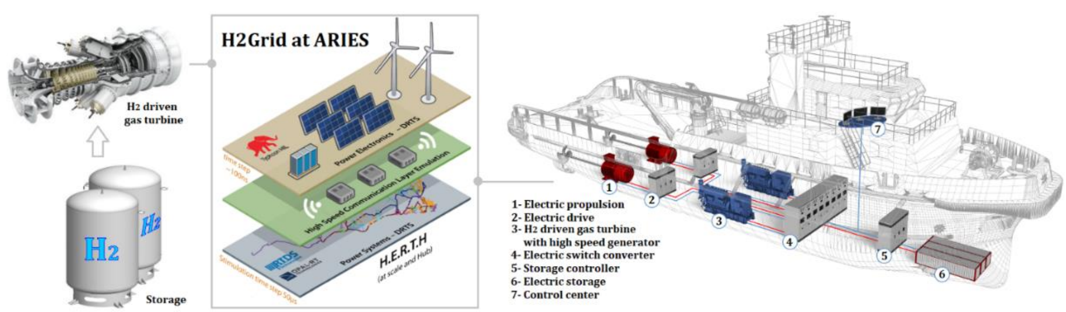

Figure 3: Hydrogen driven all electrical shipboard power system setup at NREL ARIES. The infrastructure included as a part of the H2 All-electric ship is illustrative only – the equipment is flexible and can be optimally located to maximize the ship's real-estate

10. Are there systems integration or prototyping facilities available or needed that could benefit the project and de-risk large-scale deployment? Please describe any testing facilities that could be used or are required.

Comment
This has been addressed in #9 above.

Additional Information

11. Please provide any other information that would be relevant to determining appropriate hydrogen demonstration projects and associated locations.

Comment
Ports are ideal locations to serve as green gateways for hydrogen production, storage, movement and use. At the interface of land and sea, ports offer connections to each part of the hydrogen value chain that needs to be scaled. Ports are the center of industrial innovation, and they are the best place to roll out new fuel technologies and achieve scale. Another consideration for the maritime industry perhaps lies in engaging Next Era, Cummins, Excelon, Plug Power, Air Liquide and the other companies currently investing in electrolyzers for other purposes, particularly if they are considering a location proximate to a commercial harbor.