THE BROOKINGS INSTITUTION

FUELING THE MARINE SHIPPING INDUSTRY: A PROMISING NEW MARKET FOR LNG?

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PANEL 1: EVOLVING POLICY, REGULATORY, AND ENVIRONMENTAL FACTORS

Moderator:

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Panelists:

JAMES CORBETT
Associate Professor, College of Earth, Ocean, & Environment
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CAPTAIN JOHN MAUGER
U.S. Coast Guard

JOHN GRAYKOWSKI
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PANEL 2: EMERGING OPPORTUNITIES AND BARRIERS TO ADOPTION

Moderator:

CHARLES K. EBINGER
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Panelists:

JOHN HATLEY
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President and Chief Executive Officer
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P R O C E E D I N G S

MR. EBINGER: Good morning, ladies and gentlemen, and welcome. We're delighted to have and I'm particularly delighted to have at least I think a number of new faces that we don't typically see at some of our Brookings events, and we're particularly delighted to welcome you all here. And before proceeding I want to give special recognition to Jason Toma, our fellow from the Coast Guard for the hard work he put into making this panel possible and identifying critical speakers. So thank you very much, Jason.

This is an exciting topic we're looking at today, the subject of how we can use greater volumes of LNG both in our military ships as well in civilian cargo. I think we have an outstanding set of two panels of speakers who are well versed on the subject.

So without further ado let me just say I am Charlie Ebinger for those of you that don't know me. I'm a Senior Fellow in the Energy Security and Climate Initiative here at Brookings, and I personally am delighted to have you all here. Our first panel, I will introduce each speaker as we go. We are going to commence with John Graykowski who has over 30 years of professional experience in government and in the private sector. His government service includes 15 years as a professional staff member in the U.S. House of Representatives and the U.S. Senate, including a role as Legislative Director to a U.S. Senator, and Maritime Counsel to the Senate Commerce Science and Transportation Committee. In 1994 he was appointed by President Clinton to serve as Deputy Maritime Administrator in the U.S. Department of Transportation, and later served as Acting Administrator where he managed implementation of the National Shipbuilding Initiatives and development of the Marine Transportation System Initiative, as well has having direct oversight and involvement in all aspects of the Agency's programs.

John's private sector experience includes work in three Washington, D.C. law firms -- we won't hold that against him -- and as Senior Vice President and General Counsel of Aker Philadelphia Shipyard. Since 2005 he has been a principal in his own firm, Maritime Industry Consultants where he has continued providing a full range of

professional services to maritime and transportation clients. Most recently he has been working with Marine operators on the development of liquefied natural as a marine fuel, and he was directly involved in aspects of the first Marine LNG conversion project in the United States. He frequently participates in national conferences as a major speaker discussing the regulatory and market challenges that will affect the broad adoption of LNG as a marine and transportation fuel, and has authored several articles in marine industry publications. He received his undergraduate degree at the State University of New York at Brockport, and MA degree from George Washington, and a law degree from Catholic.

It is my pleasure to welcome John. And let me just say that this is a subject of great interest to Brookings. We have been very involved in the whole LNG export debate and we're delighted to have such a distinguished group here with us today.

MR. GRAYKOWSKI: Thank you, Charlie. And good morning, everyone. I've been asked to sort of give the global view of why LNG for marine, where it is, where we're going, o where I think it's going.

So in terms of with LNG for marine, a little history lesson. Before 2010 the shipping industry was potentially the last large emission source that was unregulated. Landside transportation were all sort of in the process of being regulated. Ships do consume an enormous amount of fuel, but on a per freight ton mile they are very efficient and they are low emission. But if you take the 50,000 ships ± that operate in the world, clearly you can see that there's an aggregate sort of emissions source that needed to be addressed. Before 2010 ships could burn fuel with a sulfur content of 4.5 percent. Very dirty, very cheap. By comparison, in 2010 the U.S. EPA limited on road diesel fuel to 0.15 percent. So that gives you a range of comparison between where EPA has moved on the land side and why perhaps our air is much cleaner today, and the shipping industry.

Starting in 2012 the International Maritime Organization, the IMO, mandated that all ships had to reduce the fuel sulfur content to 3.5 percent, with a further

reduction scheduled in 2020 to 0.5 percent. These are significant cliffs that were created. At the same time the IMO said to its member states if you want to go faster and more stringent you can create what are called special emissions control areas, ECAs. On enactment of the IMO standards Northern Europe and the United States implemented emission control areas, ECAs. That's kind of what brings us here today and brings LNG to the forefront.

The regulatory actions were literally an electric shock through the marine industry and these two regions. Operators had three compliance options; the rates are there, they are not going away. So either you buy higher fuel, compliant fuel, which is low sulfur diesel, you can install exhaust gas scrubber systems, or find a way to convert to an alternative fuel to achieve compliance. Purchasing compliant fuels, an immediate 30 percent increase in fuel cost on August 2, 2012 when the ECAs became effective, and another close to 30 percent increase January 1, 2015 when the standard went from 1 percent to 0.1 percent in the United States. So option one. Option two, scrubbers. Unproven technology, very expensive to install and maintain, and they create a new waste stream, so it causes a pause. Third option, look at LNG. LNG offers a long-term fuel cost savings, enables owners not only to meet but to exceed all current and projected emissions regulations. For SOx, PM, big progress on NOx, and achieving a significant reduction in CO2. On the other hand, the first two options just guarantee minimum compliance with the ECA standards.

So essentially a fortuitous confluence as I call it of growing energy supplies -- I hesitate to use the word "boom" in the context of LNG for obvious reasons (laughter) -- falling prices for natural gas, and inescapable regulatory mandates engendered this growing interest in LNG in the marine industry. But where are we? Development in the United States has been led by first adopters. There are approximately 36 vessels under construction today that will either use LNG on delivery or configured to use LNG at some later date once the infrastructure is available.

The first LNG fuel vessels will be serving the Gulf of Mexico oil field later

this year. The first large container ship will be operating on LNG between Jacksonville and Puerto Rico by the end of 2015. By 2019 in all likelihood there will be LNG fueled ships in every U.S. domestic offshore market. To date, however, only one major international carrier has adopted LNG and is moving toward it with new vessels, and that is the United Arab Shipping Company owned by Qatar which apparently has a lot of gas from what I understand. The rest of the global industry, the major liar carriers, as they're called, seems to be hanging back, one to wait for more certainty with respect to infrastructure particularly in the United States which is the world's largest market, and secondly, to see whether the IMO will delay the further reduction from 3.5 percent to 0.5 in 2020.

In the United States LNG development has been essentially driven by sort of a market driven approach, and thus the development in my view has been more or less disparate and sporadic if you will. Different parts of the country not really targeted to the major port areas necessarily, and there is sort of a project in Jacksonville, Gulf of Mexico, Tacoma, Washington, but there's no real sort of strategy in this country that says okay, this is where we're going. Europe on the other hand has pursued an aggressive and very focused LNG strategy, employing a carrot-stick approach with increasingly more stringent regulations and subsidies to support the development. They spent approximately $150 million to date to develop LNG infrastructure in Europe. All 26 member nations of the European Union have agreed, unanimously supported a policy, formal policy, that says there will be LNG bunkering capability in all deep sea ports in Europe and all inland ports in Europe by 2025. Unanimous decision, formal policy, and money flowing to support and achieve that policy goal. By the end of this year several of the major ports, Rotterdam for one, will have bunkering capability. Rotterdam is among the world's 10 largest ports in the world.

China also has a national declared policy to implement LNG throughout its marine industry starting in the inland side by 2020. And China has a track record of once they say they're going to do something -- look at solar panels or shipbuilding, they

typically make great progress toward achieving that goal. Singapore, the world's largest bunkering port, formal policy; LNG bunkering will be place by 2020. And just last week Canada announced an accelerated depreciation tax incentive program to support the construction of LNG related facilities.

From my view LNG is here, it's not just coming, it is here and taking hold in many places, both in the United States and around the world. So what are the challenges? In the work I've done it's been pretty remarkable. Number one, LNG is new to everybody. There are no existing templates, nothing to follow with respect to regulations and marketing and market relationships, and contracts because it doesn't exist, it's a blank piece of paper. Almost surprisingly there aren't really technological challenges to either making or using LNG as a fuel where only the constraints that I've experience and observed are on the market side, and bringing together nontraditional sort of parts of the market. In this case gas suppliers and marine operators which have no historical relationship. Don't know each other, never played golf, never had dinners, haven't bought fuel. Now you add to this, because LNG is bigger than any one sector in my view, the potential stakeholders in putting together an LNG project include suppliers, marine operators, the ports, regulatory agencies, potentially maritime unions, both on the ships and in the ports, the Longshore Unions. None of these elements are traditionally aligned. So what we have to do is knit together or bridge these disparate and non traditional allies

Consider this, for over 150 years the marine industry has been buying fuel on a spot basis, first coal, now oil, price quality, transparent. It's everywhere. Ships either buy fuel on the basis of barrels of oil or metric tons. And ship owners have never given a thought to, is fuel going to be available. They just pull into port and there is always a bunkering operation that they can buy the fuel from. With LNG what I found, the first and most frequent recurrent question is if I build a ship and invest $150 or $200 million in a new vessel will LNG be available; will the fuel be there in the port. And that's ship owners here and that's ship owners internationally.

The gas industry on the other hand has, in my knowledge, operates on the basis of long-term take or pay contracts which then provide the sort of credit if you will to finance the investment in the plants. That's just historically how the gas industry has operated. Gas is sold on an MMBTU basis or cubic meters. So you already have sort of the common languages spoken by the two sides in the equation. You throw in the fact that LNG is less energy dense than diesel, which means you have to buy more fuel and build larger tanks to get the same amount of energy. Larger tanks equals potentially a loss of revenue cargo space on a ship; big consideration because where do you put the tanks, do you lose boxes. That means I'm losing money. Big issue. There are no uniform federal regulations to govern the development of these small-scale marine terminals.

Existing federal regulation is basically divided between the Coast Guard and the U.S. Department of Transportation, PHMSA, Pipeline Hazardous Material Safety Administration. They operate under terms of a 1986 Memorandum of Agreement allocating regulatory authority between the two agencies. The regulations if you read them are predicated on large import at that time, and now export facilities which involve hundreds of acres, millions of tons of LNG per year, and flow rates of LNG greater than 12,000 cubic meters an hour. By comparison the small-scale terminals that are needed for the marine industry involve maybe 200-400,000 tons of LNG per year, can be cited on 30 acres, and flow rates 95 percent less than those in the large scale plant.

MR. EBINGER: John, excuse me, but could we --

MR. GRAYKOWSKI: Yes.

MR. EBINGER: We're going over time. If you could summarize.

MR. GRAYKOWSKI: Yes, I'm almost done.

MR. EBINGER: Thank you.

MR. GRAYKOWSKI: So the Coast Guard has done a heck of lot of work, very good work and positive work with respect to addressing the regulatory uncertainties, but they can't do it on their own. So we need, if this country has the will

and the commitment, to address the issue of declaring LNG to be in the national policy because of the benefits it offers, because of the economic impact it will have and to move this country forward as other nations are doing. That's the challenge we face today.

Thank you.

MR. EBINGER: Thank you very much. Very interesting.

Our next speaker is Captain John Mauger who is currently assigned as the Chief of the Office of Design and Engineering Standards at Coast Guard Headquarters. Captain Mauger is responsible for developing and promulgating national regulations and standards governing the safe design, construction, and operation of ships and shipboard equipment, including hull structures to build all the electrical and mechanical systems, lifesaving and fire equipment, and safety measures. Sounds like you need a staff of about 400.

Captain Mauger represents the United States on several committees and subcommittees of the IMO and is currently serving as Head of Delegation for the development of the gas fuel code for ships. Captain Mauger is a 1991 graduate of the Coast Guard Academy and earned his Master's Degree from Worcester Polytechnic Institute and the Industrial College of the Armed Forces. He has served in multiple engineering assignments during his 23 year career.

Captain, we're delighted to have you.

CAPT. MAUGER: Thank you very much, Charlie. Good morning, everybody. I think my comments will fit in nicely with some of the comments that John made and then transition into Dr. Corbett's comments as well.

This LNG as fuel market is taking place in the broader context of some substantial changes in the U.S. economy right now. The Commandant of the Coast Guard, my boss, talks about it terms of an energy renaissance, this new availability of energy resources in the U.S. I think everyone here probably knows the stats so I'm not going to go through them, but in the last few years we've seen a major shift in U.S.

energy resources, and the maritime transportation system plays a key role in adding value to those resources by getting them to market. The industry is changing rapidly to meet these demands and the Commandant gave instructions to use to ensure that the Coast Guard engages and keeps pace with the industry. His instructions are quite simple, the Coast Guard will facilitate commerce, we won't impede it.

So LNG as fuel is one of those areas that we look at where we're faced with these challenges of a complex industry and how do we put the right standards in place and have the right compliance regime to make sure that we're facilitating commerce without impeding it. As John mentioned LNG as fuel is not an abstract concept. And two weeks ago the Harvey Energy was the first U.S. vessel to take bunkers in the U.S. in several decades, LNG bunkers. MSO Mobile, our field office, oversaw the LNG transfer operation. And a few months from now Tote will deliver the first U.S. flag RoRo container ship to operate on LNG as fuel, and they'll take LNG later this year as well.

So these are big changes that are going on and there are a number of other projects that John mentioned. And John also highlighted some of the potential for LNG with regard to the size of the market, and then also some of the challenges ahead. The Coast Guard is approaching those challenges of LNG as fuel using the same authorities and the same operating concept that we use and apply today for other issues. Our overriding goal is to promote a safe, secure, environmentally responsible, and efficient maritime transportation system. As a regulator we do this, we bring this about by regulating all aspects of that maritime transportation system. We regulate and certify the mariners, the vessels, the waterways that those vessels transit, and then the facilities as well where those vessels dock. Our concept of operations for this issue is the same as we've applied today, it surrounds three key elements, standards, compliance, investigations. We develop the technical standards by which we certify all those elements, the regulations, you know, for those different elements of the MTS, we have field inspectors, boots on the ground, that are out there assessing compliance with those

standards and providing input back to the standards process when needed. And then when casualties occur we actively go out and investigate those casualties and drive lessons learned into our compliance and standards process.

So with this model in mind what I want to stress with regard to the issue of LNG as fuel is that the Coast Guard has the necessary authorities, operating concepts, structure, policies, to effectively regulate these issues. We already have standards in place related to fuel system design, mariner certification, and the storage and use and transfer of LNG in the maritime environment. To date our focus with regard to LNG as fuel has been on adapting the standards that we already have to this new problem. John mentioned this briefly with regard to we have these large ocean going ships carrying LNG, gas carriers carrying LNG primarily for import, big facilities. We have standards for those mariners and those facilities, but how do we apply it to the smaller and more diverse scale for the LNG as fuel market.

Rather than hit on the details of our policies what I wanted to do was highlight three key issues that are in our minds as we're working the development of these standards and our model going forward. The first thing that I wanted to stress is that as we apply these existing standards to this new problem we have to really be aware of the latent assumptions that are in the existing standards. So in many cases we're not developing first principle solutions to this problem. We're looking at what we've already done, the models that are already in place for the carriage of hazardous material or for the transfer of cryogenic liquids and applying it to this problem. And so as we scale these issues we need to make sure that everybody understands the latent assumptions that are in the existing system.

Response capability is one that I'll highlight quickly. So today when somebody is delivering an oil bunker barge to a port nobody thinks about the response capability, what happens if we have a fracture in that oil tank. Because frankly we have a lot of response capability in the ports to handle that. It's a routine process. We pull up an empty barge and transfer the damaged fuel to the empty barge and we proceed with any

other clean up that needs to happen. But as we look at LNG as fuel and the hazards that are associated with carrying LNG in bulk we have not response capability built into our standards now for fractures to LNG tanks. How will we handle the material, where will it go, what will we do with it, and what will we do in the interim.

So that's an idea, that is we're developing these design and operating standards. We need to focus on all the assumptions that are underlying in our framework and make sure we ferret those out. We have a strategy for doing this, but it's a difficult and complex problem because John mentioned we're cutting across segments of the industry that haven't talked to each other before. The barge shipyard delivers a barge to spec; he doesn't know how the owner operates it and what they're intending to do with it. The owner doesn't know what went into the barge work at the yard other than that it meets the standard, and so on down the line. So we've got to come up with a plan to drive across all of this and understand those latent assumptions in our model.

The second thing that I wanted to talk about was diversification of risk within this LNG as fuel market. LNG in the maritime trade right now is a relatively small market in that there are a small number of players, high barriers to entry, and there are a remarkable set of industry standards that go along with that. And so the Coast Guard as a regulator sets a floor for that safety level regulation but realizes that the industry has come up with very tight standards for chartering, vetting, for application in this. And as a result they have a remarkable safety record in this gas as cargo business. As we diversify and open up the LNG as fuel market we're looking at a much broader range of players and we're looking at lower barriers to entry, so our regulations are going to play a much more important role in setting that level of safety standard.

The last thing that I wanted to hit on in terms of the things that are on our mind is the environment -- where LNG as fuel fits into the broader environmental debate. I'm not talking about LNG exports and the energy policy there, but rather the environmental benefits of transitioning to LNG as fuel, the SOx and the NOx, those types of things. Everybody can look at that and we've heard loudly in the market about the

benefits of clean burning LNG as fuel, but as I think Dr. Corbett will highlight, when you talk about methane slip, when you talk about the lifecycle costs in terms of the environment from development, production, transportation, delivery, burning, the environmental benefits of LNG as fuel are a little bit murkier. So why is this important? Well, we recognize that there is vocal segment of the public right now that is against any type of fossil fuel development. In 2013 I published a standard to propose -- a proposed policy for the carriage of shale gas wastewater or frack water on the upper inland river system from the Marcellus Shale. In 30 days we received over 70,000 comments to that proposed policy letter, most of which were against fracking in general. So we need to be aware of this context because it shapes how we have to interact with the public in this. It doesn't change our participation or our understanding. That debate won't change the fundamental way in which we approach the problem or the fundamental way in which we ensure the safety, security, environmental responsibility, and efficiency of the Maritime Transportation System, but it's something that we need to be aware of.

And at that, I'll conclude my remarks and turn it over. Thanks.

MR. EBINGER: Thank you, Captain. Very provocative conclusions there at the end of your talk.

Our final panelist is Dr. James Corbett who is a Professor in the College of Earth, Ocean, and Environment, with joint appointments in civil and environmental engineering in the College of Engineering in the School of Urban Affairs at the University of Delaware. He is a principal partner in Energy and Environmental Research Associates which is engaged in energy, environmental, and economic analysis for clients internationally. Dr. Corbett received his Ph.D. in engineering and public policy from Carnegie Mellon University where he also earned Master's in Science Degrees and Departments of Environmental and Public Policy and Mechanical Engineering. He is a graduate of the California Maritime Academy and has worked as a License Officer in U.S. Merchant Marines, a Naval Reserve Engineering Duty Officer, and as a consultant for industry and government in industrial operations. He is an extremely prolific writer with

over 175 publications -- I'm not sure we have anybody at Brookings that can match that -- related to freight and multimodal transportation. In 2000 Dr. Corbett co-authored the IMO study on greenhouse gases from ships, the second IMO greenhouse study again in 2009, and the IMO greenhouse gas study in 2014. He is a recognized professor for his groundbreaking research in air emissions for maritime transport and we are delighted and honored to have you here today.

DR. CORBETT: Thank you very much. What I want to do is just begin with one version of my takeaways and then I'll go through them a little bit in more detail.

The foundation that we've heard from the other panelists, from John and John, are very, very helpful for me to stay brief and on target. To begin the marine sector needs to, will, and is engaged in becoming less polluting. And it's not only because they may be among the least regulated or most sturdy, it's their turn in a sense. So in a sense the good news is you're going to see gains in the environmental performance of the shipping center that will far outpace the year on year gains over the next decade, maybe two because we got to start later so our gains are going to look better. Some marine applications will -- and I'm going to use this word knowing its value laden -- deserve to adopt LNG. And the question really is which parts of the marine applications, which parts of the marine sector deserves the LNG, and that's a three way question around price, around performance, and around pollution, at least in terms of the impacts that near port communities and coastal communities have.

One of the things I'm going to spend a little bit of time on is thinking about this in a century scale context rather than or intention with a 2015 prospector's perspective. And that's an important difference. The best fit fleets for investment may not be the dirtiest in the maritime sector. And the dirtiest deep water fleets may not be U.S. flagged, are not U.S. flagged. And the U.S. flag vessels are not limited to what we might call deep water. They include ships of course, tugs, service tugs, harbor vessels, platforms, supply ships, et cetera, like the Harvey, tugs and tows in the inland river system. It's a very diverse set of opportunities when we think about an LNG conversion

potential and where to start it and where it should be emphasized within the marine sector.

I'm going to spend a little bit of time talking about the environmental and emissions tradeoffs, but I'm going to be using what's called a total fuel cycle concept or context. That means we're going to think about the releases of pollutants from the point of extraction, transportation and processing, and bunkering and operations, all the way through the life cycle of the fuel. And that's important because with natural gas there are a number of upstream factors before it ever touches the dock and the ship that can change the sign of the comparison in terms of the greenhouse gases which will be one aspect of what I might pick up on is the socially responsible part of this.

On an emissions basis, if you think about emissions as pollutants in the more Clean Air Act, last 30-40 years context, LNG is good for reducing SOx emissions, sulfur, good for reducing PM, and it might be good for reducing CO2, but when you consider the methane, especially on the fuel cycle, it has a climate neutrality that we may need to debate. There are some innovations and breakthroughs that could change that sign, but it isn't yet clear when you pick diverse upstreams. One take home on that that I'm previewing is that if you can consume more locally with less distance travelled and less storage, you can stay on the more neutral or positive side of the social responsibility greenhouse gas sign. LNG can also be an enabling technology, or an enabling fuel for reducing NOx emissions which is an ozone precursor. So that's the last big regulated pollutant that I'll talk about.

The point is that the marine sector really has an opportunity here to be a part of an LNG insertion into the transportation sector and an LNG demand center for domestic energy, but it might also miss the boat. And I want to spend a little bit of time leaving some seeds that maybe will be picked up more in the next panel. At the end of the day one of the way to sort of think about that summary is that we're at the edge of a pretty great achievement, similar to 1914. And I'll spend a moment talking about that. As of the turn of the last century we were converting from coal to oil. When we converted

from coal to oil vessels didn't invest right away. There was a lot of uncertainty, some delay in investment. But in the late 1800s the conversion to technologies were proven and became market ready. By 1910 or so the majority of the fleet was still under sail or coal, but the majority of cargo was being carried by motor, some of it steam powered but oil fired. And one way to think about this conundrum is that then we moved through the World Wars into the 1940s, '50s, and a colleague of mine -- I love this story; I've got to tell it -- is that you essentially presented the marine sector with two different kinds of fuels. A distillate fuel that you would like of as being reasonably similar to what you're used to in a diesel engine, and another fuel that was black and ugly and full of contaminants and smelled bad. And they said which d you want? And they said well we want the clean stuff. So they dropped the price. They said which do you want? They said we want the clean stuff. And they kept dropping the price until you got about a 30 percent difference and then the ships said, you know what, we'll talk with the engine guys and we'll figure this out. We'll take this fuel. And a deal was struck in the 1950s that said you can always have the cheapest fuel for your ships, maritime sector. There's only one condition, its quality will always get worse. Well, now we're in 2014 and we're going through another 100 year investment change in which the fuels have to get cleaner, at least within 200 miles of North America, at least in emissions control areas. And that's opening up the set of opportunities that John talked about.

So the questions that drive me are how much LNG can the marine sector be expected to adopt? What's the eventual demand in the marine sector? And the other question that drives me is how much share of the transport sector can the marine sector take as LNG? Because if LNG is going to be supplying a lot of different trucks and trains and tractors, agriculture, fishing, whatever, you work your way around all that fleet, is there enough LNG to go around? And the answer is yeah, maybe, except at what price. And we made a price statement at the early point that it's cheap. The prices are all forecast to converge and to start to firm up as demand firms up.

So what are the reasons to consider LNG as a marine fuel? We've

covered this three different ways, four different ways. I'm going to put it into a context that says that we're looking at a fuel that could give you compliance with all current and prospective regulations for the life of the turnover of your fleet if you're an operator. In other words, and as these guys said, but I'm going to put in shorthand, it's like the kind of qualities -- LNG promises the kind of qualities that you'd want in a dear friend of one of your children, right. Clean, affordable, and socially responsible. It promises to do those things and it delivers so far on two of them very well. It's cleaner than most of the other fuels, or it's a clean fuel enabler for other controls. In terms of affordable, it's been affordable for the last decade or more. If you look at it on the world market, North American LNG has been more affordable than the world average price for more than two decades. So it's got that going for it. And socially responsible, if we talk about it just with greenhouse gases it really depends. Some work that we've done that I can point you to later in discussion has talked about the climate neutrality, the bit of a tradeoff between low sulfur fuel oils or the distillate marine fuels, and natural gas. And that's the comparative that really matters given that we already have an ECA and the heavy sulfur fuel oils are already out of the picture.

Reasons to be uncertain about LNG though include that GHGs might be this higher or neutral thing and infrastructure needs are really substantial. The marine sector, the ports themselves are major bunkering, major fueling locations that count in less than 100 for the United States and maybe around that number mostly, depending on how you want to trim it, for the world. The places that most of the fuel is sold are really few, very centralized, and have a limited number of operators. But if we can't get LNG to those locations then there won't be able to be a consumer. It's sort of imagine the guy on the desert island, what's he looking for, he's looking for a boat, and the guy in the boat who is stranded and he's floating at sea, he's looking for land. And they can see each other but they're not sure that they can meet yet. That's the challenge with infrastructure and technology.

And then the conversion will need a network, a bridge, because the

RoRo going to Puerto Rico and back to the mainland U.S. has a really good opportunity to succeed because there is infrastructure at both ends that can be understood and controlled and the trip is rather short. But it's not necessarily a triple bottom line winner.

So again to repeat, the question is whether this LNG is a uni fuel like the last five decades or whether it's a multi fuel. The drivers for the pace of transition for investment and for demand include air quality, we hit that, include the social commitment to reduce GHGs, we hit that, include infrastructure and technology and price and demand. And when you look around the world at those five factors, North America is fairly well positioned to take advantage of this and it's not unique to the marine sector. The transportation use of LNG in North America has far outweighed the transportation use of LNG in any other IEA sector, in any other energy-consuming sector around the world. What we need though is a 2050 vision of LNG leadership, but we're looking at 2015 industry and government investment decision makers jointly. The main threat would be the long run price.

I think at that point I want to just finish with this, one of the things that happens when you go to Worcester Polytech is you learn about fire protection. And the fire triangle to make combustion happen includes, you know, oxygen, heat, and fuel, et cetera. The fire triangle for getting a conversion from coal to oil pretty much only needed those things. A little bit of pressure and it auto ignited. It was a diesel engine, not spark required. LNG requires a spark.

MR. EBINGER: Thank you, sir. In the interests of time and because we have a lot of very knowledgeable people in the audience on these topics I'm going to not ask the panelists any questions, but go immediately to the floor. We have got some roving mics coming around. All we ask is that you identify yourself and that you ask a question. Thank you very much.

Can you identify yourself please?

MS. BONDAREFF: I'm Joan Bondareff with **B**lank Rome. And John and I worked together at the Maritime Administration a while ago.

MR. EBINGER: Which John?

MS. BONDAREFF: So the question is for John Graykowski. John, you mentioned the important roles that Coast Guard and PHMSA does to regulate LNG, but we didn't talk about what the role of MARAD is in promoting this as a safe, clean, efficient fuel. And do you think we need any congressional leadership on this or new legislation to establish what that role is?

Thank you.

MR. GRAYKOWSKI: Thank you, Joan. First let me also say that in addition to the federal side everyone of these plans has to endure state and local permitting, which are additional layers, additional and certainly potential delays. Direct answer to your question, yes, I believe that if you look at the progress that LNG has made and the network of infrastructure that is being developed in the EU on the basis of a formal policy commitment and promotional support in the form of money, and the fact that they have a plan and it seems to be achieving certain benchmark goals, that that would tell me that yes, it was something that we should consider and look at very seriously in this country. But you didn't ask the question of how realistic I think that is in today's climate, and that's a whole other discussion and a whole other discussion. But yes, in point of fact I do believe LNG has the foundation for a national policy in terms of economic benefits, domestic gas supply, energy independence, new technology, new jobs, shipbuilding stimulus, that would support certainly a hard look at a national policy.

MR. EBINGER: Question? We've got one back there.

MR. CONDINO: Thank you very much. David Condino, and I work with the U.S. Coast Guard Facility Compliance area. Very interesting. And a question for I guess Dr. Corbett. If you look at the pie charts, in most of the studies the marine sector, pollution from the marine sector, including air pollution of course, it's a relatively small fraction of the total pollution from all sectors, and even in the transportation sectors depending on which pollutant you're looking at. I'm wondering, we're doing a lot of work -- I know that in my own office and I know Captain Mauger's office of course at IMO, we're

doing a lot of work to mitigate and address the problems in the marine pollution sector. Can you tell us what's being done in the other transportation sectors, especially the commercial transportation sectors, heavy road sectors and the rail sectors?

DR. CORBETT: Very good. First let me engage the discussion on what is big, how big is big. If we think about carbon dioxide emissions and we think about it at the global level, and we look at international, ocean going deep water vessels, ships are responsible or contribute about three percent -- the press release says three to four percent here, it's in that range -- three percent of all CO2 from all anthropogenic fossil combustion sources. Low number, right? It's twice Germany. Its number six out of ten if we counted it as a nation. It's not a small number because we've got 180 nations and the top 4 or 5 are more than 3 percent, but the rest are less than 3 percent of the global total. If we think about it in terms of air pollution like sulfur emissions, this is a fuel that receives every bit of sulfur you have driven out of gasoline, every bit of sulfur you have driven out of on road diesel and non road diesel in North America or Europe or Japan or any of other nations that are emerging to follow along those regulations. So it would be like saying that there's less dust in the room because I used the vacuum cleaner, but this filter is really dirty. A lot of the dust is coming, you know a lot of the contaminants that we're concerned about. So in terms of sulfur emissions, ships are a very, very large source.

Now to get to your understanding of the numbers, and I'm guessing here, so it's a discussion, if you look at the domestic inventory of fuel use or emissions for the United States -- first name again, sir?

MR. CONDINO: David.

DR. CORBETT: David. Then you can get number that makes it look rather small. But the domestic inventories are intentionally excluding most of the vessels that arrive and depart in our ports because they are international bunker traffic. And they don't capture the contribution of pollution from the shipping lanes that hug our coastlines but don't have ports. I think the number two or number once source of sulfur in Santa

Barbara County that has no port is ships. So you've got to be careful a little bit about how we're slicing it. If we're talking about U.S. Coast Guard, U.S. flag, then we can move right away to Inland River and service vessels, et cetera, and we can go there. But what is big is really an issue.

Now to hit the point of your question, tier two or three standards at least now, maybe its tier four, are applying to rail. They've been regulated for the last 15-20 years. Automobiles have been regulated, begun since the '70s. So in terms of transport sector technologies, the marine sector is able to take advantage of those innovations that have already been applied to sister technologies in the other transportation sectors.

MR. EBINGER: Back here.

DR. CORBETT: Sorry for the long answer.

MR. BEARY: Brian Beary, Washington Correspondent for *Europolitics*. Just wondering, greenhouse gas emissions, it seems like a lot of the regulation both domestically and internationally focuses on sulfur. It there rules on greenhouse gas emissions like CO2 and this coming up within the context of the climate negotiations for the Paris Agreement?

CAPT. MAUGER: I can stumble into that and hopefully these guys can help me out a little bit. So over at the International Maritime Organization, IMO, there's an effort underway to address greenhouse gas emissions through ships through improved ship efficiency. And so there are a number of efforts going on in that. I don't -- maybe one of the other panelists has the specific details on timelines or how that moves forward, but the way that that issue is being looked at is how can we make ship design, ship operations more efficient, and thereby reduce greenhouse gas emissions.

MR. GRAYKOWSKI: Well, I think Jim probably has the details, but I think both Jim and I refer to the fact that sort of coming out of the shoot very quickly after SOx -- I mean that was the easiest low hanging fruit if you will, or whatever analogy you want to use in terms of how do we attack and do you address it and the criticality. But NOx, nitrogen oxide, is absolutely barreling down the road with respect to maritime

transportation. And keep in mind sort of corresponding to that or complementing that, however you want to look at it, ports are -- and certainly in this country and I suspect in the EU as well, local sort of land based pollution regulation is ratcheting down. So you've got this kind of twin effect if you will. And as I said NOx is going to be the next candidate for attention. But, Jim?

DR. CORBETT: In a short story sort of format, regulators have relied on the economic advantage of saving fuel in trucks and trains and ships, things that get paid for a certain amount of service but then have costs involved. There's an energy efficiency incentive in the market for commercial transportation of goods. Ships have taken advantage of that with some exceptions, especially in the containerized story. We recognize now, the IMO recognizes now -- I'm just going to repeat what he said very differently -- is that it's not enough to let the market optimize for CO2. And so energy efficiency commitments are now becoming part of the design of new vessels and part of the operation of existing vessels.

There are two tracks of issues though. The consequence of more CO2 is either more cost to the industry in terms of fuel, or the social impacts of climate change. There is an important health endpoint and an important acidification or eutrophication endpoint for strong acids that are part of our pollution, the kind of pollution we don't like to breathe and we like to control out on the street that comes from ships. And that set of policies could not be handled with the CO2 stick. You couldn't address the two because they are asymmetric. If I want to save energy I make higher pressures and temperatures. That's good for NOx, bad for NOx pollution. If I want less expensive fuel I take whatever I can get even if it has some contaminants and I treat it and blend it. Bad for SOx, good for low CO2. So there are some very important tradeoffs, and what's important to note, as John said, is the IMO and the agencies are now, and the EU is now working both those sides of the street.

MR. GRAYKOWSKI: And let me just add methane. As LNG grows I suspect, and the EPA is already looking into this, but methane will be and continue to be

a concerned focus of attention because of its characteristics as an incredibly potent greenhouse gas. Shorter life perhaps, but -- so I think we all -- it behooves us to do all we can to make sure methane doesn't become sort of another issue that requires additional regulation.

MR. TAN: Hi, I'm Eugene Tan from the Carnegie Endowment for International Peace. In the mid-term market outlook of the IEA, which was released I think one or two weeks ago, they suggested that on a cost effectiveness basis diesel would be more competitive than switching to LNG or using scrubbers to clean out the residue of fuel oil, because it's more cost effective. Is that a fair assessment? And if so is it an all or nothing policy driven response to increasing the amount of LNG in the market.

DR. CORBETT: I'm really glad you ended with that second part of the question. If you look at averages and you assume the world is homogenous it is only when we started to switch fuels that anybody was caring about scrubbers or natural gas. As long as the cheapest option was legal nobody would make a better choice. In the long run I think -- long run meaning to 2050, so maybe not the long run in a century scale -- I think that LNG will be competitive in niche environments, especially where the pre existing infrastructure enables it as a choice. The OEMs, the engine manufacturers of the world are stepping up with a set of options that in a new build are price equivalent, so you can pick. And in a retrofit can maybe be cost effective in case by case basis. But you think about -- was it Saudi Arabia or Qatar that --

MR. GRAYKOWSKI: U.S. Arab Shipping.

DR. CORBETT: U.S. Arab Shipping. United Arab Shipping is going to, I predict with a total shoot from the hip which I always buy high and sell low, don't trust me, but I predict that that LNG fleet that they're going to be building is going to be serving Europe through the Med because what they are going to do is be able --

MR. GRAYKOWSKI: Yeah, that's their route.

DR. CORBETT: -- to meet all of the requirements for the EU for the life

of their fleet without ever leaving the regulated zone except on the other half of the Med which is their side, and they've got the gas to do it, and Italy or whoever, whatever port they deliver to is going to be happy to gasify for them.

MR. GRAYKOWSKI: Their principal trade route, they do call them the States, but I believe it's Far East China essentially, around the horn and then up to Rotterdam.

DR. CORBETT: That's not going to go LNG.

MR. GRAYKOWSKI: Well, that's -- it might, but I don't think it --

DR. CORBETT: That will get LNG last.

MR. GRAYKOWSKI: U.S. Arab Shipping. That's their --

DR. CORBETT: But if they serve Europe they're going to have the right conditions for an LNG synergy in terms of the design, the infrastructure, and the market (inaudible).

MR. GRAYKOWSKI: We're saying the same thing.

DR. CORBETT: Yeah.

MR. EBINGER: Michael?

MR. RATNER: Hi, Michael Ratner with Congressional Research Service. I was hoping the speakers could elaborate a bit more on what this means to American shipbuilding, how big of a deal is it?

MR. EBINGER: Go ahead, John. Start with that.

MR. GRAYKOWSKI: Personally I think it's been a significant factor to date. As I mentioned there are some 36 vessels being constructed today, Jones Act vessels, throughout the United States. San Diego NASCO is building the Tote ships, Aker Philadelphia is building both product tankers which will be dual fuel, LNG capable, as well as the two Matson vessels, LNG ready. So it's hard to quantify it, but it seems to me that -- and that's why I think there's an economic driver to a policy effort between conversions which are not -- conversions work not for everybody. I mean there's a certain class of ships, the Tote ships were particularly suited given the newness as well

as their configuration. And the Jones Act fleet is not young by any stretch of the imagination generally. But both Tote and Matson have new vessels, Crowley is building new vessels. So I think that's been a big stimulus already. If we had a more focused certain policy -- you've got some 20,000 tugs both inland and the harbor service vessels that Jim referred to that may be conversion candidates. So I'd have to say that net plus on balance there is a huge upside potential for the U.S. shipbuilding industry if we focused on LNG.

MR. EBINGER: We have time for one more question. The lady in the back.

MS. FLORINI: Karen Florini with the Environmental Defense Fund, which unlike most of the environmental community is not anti natural gas. As has been mentioned by several speakers, the impact in climate terms of LNG shipping depends largely on what's going on with the methane and methane releases. That's partly because or that is because it is a very powerful warmer as was indicated. Many people don't realize quite how powerful. At the time of initial release it's 128 times more powerful heat trapper, over 20 years it's 86 more. So these are big numbers. What is being done in the process of infrastructure development and regulatory development to try to assure that the infrastructure is in fact going to minimize methane leaks?

CAPT. MAUGER: Let me just take a first shot of it. I think that I'm going to take a twist on it, maybe too tight of a spin here, but being able to build large central anchor demands, large consuming, large energy consuming centralized demand like the marine sector may offer at ports, is one of the ways in which we can help ensure that the infrastructure development remains low emitting, the upstream remains low emitting. If you have to store fuel for a very long time the boil off creates a methane release that in some of our calculations is enough to switch over the comparison. In a long distance pipeline, if there is leakage expected in that pipeline that can cause switchover between the net greenhouse gas comparison when you account for methane.

So I think that in some ways that's happening. Certainly as the value of

the energy is being recognized that will have some degree, but there is more to do upstream.

MR. GRAYKOWSKI: May I?

MR. EBINGER: Go ahead.

MR. GRAYKOWSKI: The issue of methane slip, so called, was something that we considered when I was working on the Tote project in 2011-2012 -- John Hatley is from the lead engine manufacturer -- and it's something that I agree has to be addressed in a very vigorous and persistent manner because it helps nobody. From just a straight logic standpoint LNG is methane. Any methane that doesn't go in the tank and burn in the engine is money, right, creates a potential safety hazard. And I mean look at it from a business standpoint. The logic that drives wringing out every drop of fugitive methane seems to be compelling to me because economically it makes sense, from a safety standpoint it makes sense, but obviously form an environmental standpoint. And if you look at the companies in America that have adopted LNG as a propulsion system, Tote, Matson are two of them, I think they have a very established record with respect to respect for an aggressive pursuit of greening their operations in all respects.

MR. EBINGER: If you'd please join me in thanking the panelists for a very interesting presentation. (Applause)

We are now going to take a 15 minute break. Help yourself to some coffee. The restrooms are back outside the main door there. And please be back sharply in 15 minutes. Thank you.

(Recess)

MR. EBINGER: Thank you for being a very good audience about returning to your seats. That's not always the case here at Brookings. (laughter) Our next speaker is John Hatley, who is the Vice President for ship power for Wartsila, North America, and he has over 30 years of combined marine experience, spanning business development, project management of domestic and overseas vessel constructions,

owners' representation, ship operations and vessel design. He has a number of very prestigious degrees; you can read in your program. In the interest of time, not trying to do him short shrift, but save some time for questions, and most importantly, in 2008, he was the recipient of the Rear Admiral McCreedy Award for Outstanding Achievement in Marine Engineering. We are very thankful to have you here and look forward to it John.

MR. HATLEY: Thank you very much. It's a pleasure to be here and I want to thank you for the kind introduction. If any of you need to know more, please call my 95 year old mother and she'll tell you all about her young son. But let's go very quickly. I'll promise to be done in 15 minutes. It's a very, very exciting time for marine, especially with LNG. Lots and lots of potential. First, this is what we have going right now today for contracts in North America. Three at BC Ferrys being built in Poland, two at C-Span being built in Turkey, two at Tote soon to be retrofitted to LNG fuel, three in Quebec Ferry's. We have one in Fincantieri, Italy, two being built in Davies, Canada and six with Harvey Gulf.

LNG fuel is not new to Wartsila. It's new here. We have today over 12 million horsepower in the marine segment alone running on natural gas. Of that 12 million horsepower, it's over 600 vessels, 1200 and some engines, an equal number in power generation and land producing clean electricity for lighting. Here's my agenda. We'll look at a what, why, how and some quick conclusions about this market space. First, the opportunities are tremendous. That clock shows the Wall Street Journal's depiction of transportation fuels. Note that the tiniest sliver at midnight, two tenths of a percent, is natural gas. What a wonderful opportunity to expand. If you are clever enough to look at the EIA website and its details, you'll see that natural gas is a bit higher percentage. Read the details and the footnotes. They conclude for transportation, natural gas and pipelines. We pointed this out to the EIA that most of the public thinks of transportation as something that's moving on a purpose, not being moved to get to a market. So that would be the only difference. What do we often look at? We know what we touch and feel every day. Cars, taxis, garbage trucks, school buses, semis and rail.

Here you have a typical understanding of how many thousands of gallons each of these types of vehicles would consume in a year. Note, rail, somewhere 140 some thousand and semi's around 20,000 -- big consumers. Where is marine? When you enter into an early market phase, you want to efficiently market and control your capital and move your customers for scalability. And that means, go to a small number of large lot consumers rather than a large number of small lot consumers. Marine is a small number of large lot consumers that allows you to then capture the green light for CAPEX expansion, then everything else flows in that region.

A tug, any guesses on the fuel consumption? There it is, on an annualized basis. A typical ferry, there it is on an annualized basis. We're beginning to talk in millions of gallons. Offshore supply boat, there it is, millions of gallons now a year, or more. By the way, on the rivers, quietly moving up and down the Mississippi and Ohio, are not dozens, but hundreds of vessels like this -- there it is, we're talking millions of gallons, not 20,000 gallons for a semi. Not 140,000 gallons for a locomotive, but millions of gallons with one marine vessel, in a fleet of vessels for one marine owner. And there are many marine owners, concentrated demand. Great Lakes, self-unloader, 1000 footer, well we're up to around three million gallons. Type of crew ship, this happens to be the Viking Grace, stole the picture, we had some visitors in here, roughly six plus million gallons -- sounds pretty interesting. How about a large ocean going cargo ship? Well, here's the number -- 30 million gallons, or more. So, here's the marine scale. Note, hails in millions, not thousands.

So let's put transportation, that we saw on thousands of gallons, and obviously it just falls down to the intersection of the XY access, you can't even see even the largest contributor there. Why? There are several reasons why the market is proceeding here; a lot of it on the business side has to do with the economics. Very strong returns through last summer, even this year, many vessel cases demonstrate first or second case for LNG, because diesels plummeted. But does mean diesel will stay where it is for a prolonged period of time? Probably not -- very high returns on equity

assets and invested capital.

How clean is it? We've heard descriptions, on the right you see the gray, 100 percent numbers for a typical diesel engine, and in color now, we're going to see what it is for LNG. Great results, at the point of combustion, without after treatment scrubbers, without after treatment SCRs, without after treatment particulate matter. By the way, Wartsila manufactures all these items as well. So it tends to be at the point of combustion, ultra clean, compared to a typical diesel engine.

So those are the five game changes. Upper left you got tremendous long term shale gas supplies. Lower right, seems to be a bargain with ever lower forecast prices going forward, transecting that, lower left, you have EPA standards for sulfur content, and one to one, to one tenth of a percent, we have trouble encapsulating U.S. and Canada for instance. In the upper right, it would be engine standards at the engine itself. Those regulations have dates, don't move, and those dates set the investment clock.

How fast might this happen? We saw 16 contracts we held already, but let's look at that. Great great writer, huh? I love those stories he wrote but this is one thing he said that maybe my history teacher might not completely agree with but somewhat. History -- know it or repeat it. Well, maybe it rhymes. We heard about the adoption of shale, came to diesel. Cartoon showing S curve. What happened originally was that diesel in the 1920's was seen as a reduction in smoke and fire of the combustion and the noise of a steam locomotive, especially in shuttle areas where trains were made up, in the freight yards. So it was relegated to the little shuttle engines, and in or around tunnels. But you can see, 25,000 locomotives in five class one U.S. and two class one Canadian railroads jumped to diesel in about a 13 year rate, from the 10 percent to 90 percent position. That's very fast. Look at the change. Steam, wholly different process with the reciprocating internal combustion engine. What about marine? We can see on this graph, the green line shows the rate of adoption. You know, way back when, most merchant ships ran from five to six knots, with sails, not too bad, a big

crew, not a lot of payload. Well why was there a delay, does anyone know what the delay was caused by there, for about 30 some years? You're either all asleep or didn't read your history books. What happened? Why the delay? The clipper ship. Clipper ship was defensive technology that answered, came in with large sails, great speed, a small crew and lots of cargo, and it ran at lower cost, so that was the three decade delay. And it took off again, and we heard from Dr. Corbett about 1910 or so, that's the adoption rate. What a profound change. Sails, steam, diesel eventually. So what's going on in the market today? Let's look at some signals, because it's very apparent. We heard earlier, there's a number of vessels. This is a headline; we're soon going to eclipse Europe. Note, Jacksonville, T-Star, moving forward. Gas is coming in. Pivotal, LNG and Westpac. February, Harvey Gulf started putting in the first LNG fueling station on land for marine. February, loader ship. Great company Tote, went with Wartsila to repower the two fairly young ORCA class ships who carry a dominant, almost third of a share of all cargo to Alaska, clean, green, proven power, we have totally in horsepower use today, it will run and run very well.

Did you notice in February that Maritime Title XI may incorporate some conditions allowing blessings for environmental technology ala LNG fuel? Well that's great because is capital is guaranteed, banks will load to qualified responsible borrowers. That's a fabulous rate and you'll see in a minute how that impacts industry. February, Tote started cutting steel, bunker barges coming on stream, several designs, and it isn't rocket science, but it kind of is. Doesn't that kind of look like a kind of rocket ship? So big (inaudible) are identified as a key need going forward. We had to get local supply. Crowley began even small scale containers, ships being built, Crowley. Remember the mad guarantee program? There it is. Four hundred and fourteen million for Crowley and 360 some million towards Tote. BC Ferry announced three new ferries being built with us. Mare says the paint is pretty great if we stay in the ECA. Leespan ordered two new ferries to be built in Turkey with us. Help from Fordus BC, a local distribution company provided gas in the area. River boats, in December of this year, jumped to January,

supply field going forward, for Tote. Harvey Gulf, you can see the entire kit there, from the engines, the power tank, the bumper stand, everything from us, it's integrated with the integrated automation alarms control systems.

There's a picture you won't see that is given to me by Harvey Gulf showing a historic load out of LNG for the first time ever, July, in February, not 6th, go to the 9th, Crocker Vessel for Europe, with us, for the 25th of February, just a few days ago, first LNG bunker barge for the United States and Canada, Conrad's going to be building it, 26th of February, daily lease keel for that LNG fuel ferry. We got a lot of mathematicians, besides, who was keeping count?

Oh, I failed. That's what the CAPEX is today. That's the fuel demand today, as of close estimate. Excluding the dozen or so Jones at LNG ready vessels in the market, these are the LNG fuel vessels in the market. What's going on? Green is easy street, yellow is a challenge, red is tough, purple is also tough. That shows you, unless you're color blind, that mid-decade, the early adopters are going forward, and the early followers in the marine market will soon come, for all those reasons. We hit it. What, why, how, conclusions and then I get done in, close enough to 15 minutes? Thank you very very much. (applause)

MR. EBINGER: Next panelist is Ben Semmes, who is a Senior Financial Analyst at Cheniere Energy based in Houston, and of course, it's Cheniere that's coming forth with the first LNG export facility, hopefully by the end of this year. And I particularly want to thank Ben for coming today, because he A, came from afar, and B, came with very short notice. And we're very thankful for you doing that. Since joining Cheniere in 2012, Ben has worked with a small team responsible for company-wide financial modeling, valuation analysis and mergers and acquisitions. He has led Cheniere's due diligence efforts in support of potential investments across the energy landscape, including a startup pursuing LNG as a marine fuel. He began his career as a newspaper reporter, holding positions at several publications in California and Pennsylvania, and he graduated magna cum laude from Colgate University in 2003, majoring with honors at

American History and Spanish literature. In 2011, he graduated with an MBA from the Tepper School of Business at Carnegie Mellon. Ben, we're delighted to have you.

MR. SEMMES: Thank you and thank you Dr. Ebinger and the rest of the panelists and the audience, very excited to see that everyone's here. This is sort of our bread and butter and we enjoy talking about it, and very excited to see the interest here. I'll speak for a few minutes and then dive into some of the details on the infrastructure challenges of LNG as a marine fuel and during the question and answer. Cheniere Energy is building a large scale, world scale, LNG export facility in Louisiana. That's as Dr. Ebinger said, expect to come on line at the end of this year, and to give you an idea of the scale of this facility, at full production in 2017, 2018, Cheniere will be exporting from this facility alone, two and a half billion cubic feet a day of gas. And some comparison -- the U.S. currently produces a little bit more than 70 bcf a day of gas. So significant number, in a yearly term, that's about a trillion cubic feet a day of gas that Cheniere will be exporting.

As part of this process to develop this terminal, we've looked at other domestic, or we've looked at domestic usage for LNG, specifically LNG bunkering. And in some ways these two markets couldn't be more different, and so you might wonder why Cheniere would be interested. To give you an idea of the relative sizes of the markets, we've heard a little bit about this. The current size, what we're really doing is we're replacing this very dirty type of diesel that's used in shipping and it's really the last, as you've heard, last part of U.S. industry that is still using this fuel. And it's about six billion gallons per year of this, of diesel fuel, that is used in the marine industry for marine bunkering. About 75 percent of that, roughly, is the very very dirty type of diesel fuel. So that's the target market and to think about that in gas equivalent terms, that's about 800 bcf a year, so going back to Cheniere's production from the facility coming on line, hypothetically, Cheniere could supply the entire marine fleet in the United States with this plant, so you have a trillion cubic feet a year. That total market is about 800 bcf a year. So very different markets -- international, domestic, but what we realized after thinking

about this is that what's really driving the change in both markets is similar, and I break it down to two things, really, two big things. Environmental regulations, that you've heard about, from our other panelists, and a long term view on price. So our off takers at our export facility, are making a 20 year bet on low gas prices in the United States as well as benefitting from a cleaner fuel.

In the shipping industry, the challenge is to convince ship owners and charterers to make that same bet. Our company has made an investment, a recent investment, in a startup LNG bunkering company that is working out the infrastructure challenges to target the port of Houston, so that really, the Houston ship channel, which is the largest bunkering port in the United States, and we'll get into that a little more. I think that one of the things that's -- it's hard to say from a price perspective that the recent drop in diesel fuel hasn't given a lot of ship owners' pause about using LNG. The one bright spot there, really in our view, is that gas prices have fallen along with oil prices, and it sort of makes me think of, just talking to a friend who grew up in Mexico, and he said the joke there was that the state oil company, MX, if oil prices went up, prices at the pump went up. If oil prices fell, prices at the pump still went up, and that's because the state oil company was running out of money, so they needed to subsidize the monopoly.

In the U.S., we have the opposite problem, and I think Dena's going to talk a little bit about this. For the first time in ten years this winter, in the northeast, as demand rose for natural gas, because of very cold temperatures, for the first time in ten years, and this happened on a dozen occasions -- more than a dozen occasions, the spot price for gas in the United States fell. And there's a host of reasons for this, but we think it gives our customers comfort that low gas prices are sustainable. So with that, I'll pass it to Dena.

MR. EBINGER: Thank you very much Ben. Our next speaker is indeed, Dena Wiggins, who is President and CEO of the Natural Gas Supply Association, where she represents major integrated and independent natural gas producers in the United

States. She joined NGSA in 2014 and in her role as President; she leads the association's efforts to encourage the supply and use of natural gas and promotes the benefits of competitive markets. She also serves in a very important role in the Commodity Futures Trading Commission's Energy and Environmental Markets Advisory Committee. That's quite a mouthful, which advises CFTC on preserving market integrity and competition and energy futures markets among many other critical issues. Previous to joining NGSA, she was a partner at the firm of Ballard Sparr and served as General Counsel to the Process Gas Consumers' Group. She holds a B.A. degree from the University of Richmond and a J.D. from Georgetown University Law Center, and we're delighted to have you here today.

MS. WIGGINS: Thank you Charles. Well it seems to me that whenever there's a discussion about a new use of natural gas or an increased use of natural gas, the question comes back to, okay, if we use it, are you going to be able to be there to supply it? And part of what I thought I would cover today is what I typically call the good news story for natural gas. There's a lot of gas there, the resource estimates have increased dramatically. In 1966, the resource estimate of recoverable reserves was 600 trillion bcf. A couple of years ago, that resource estimate rose to 2384 bcf. So there's a lot of gas in the ground. Now of course, gas in the ground doesn't help you all who are trying to use it for marine uses or want to export it, or my former industrial clients are trying to use it to make fertilizer and build factories and made steel and those sorts of things. But in addition to the gas in the ground, the production numbers have also increased dramatically. This winter I think we were at record levels of production at 72 bcf a day. EIA's estimates show that those production levels are going to increase next year to about 74 bcf a day and by 2020, EIA projects that production will be at around 100 bcf a day. Those are huge huge numbers. Not only is the production going up, but if you look at the map that you put up there, briefly earlier, you can see that the production is geographically diverse. We typically thought about gas being produced in a relatively few states in this country, and thanks to shale, that has also changed dramatically. If you

look at the map of the United States now and look at where the production is coming from, except for a handful of states, you can find production in many, many states in this country. Now, you've got to have it in the ground, we have to have it produced. We also have to have the infrastructure to get it to the people who need it. And on the pipeline side, the federal energy regulatory commission has done an amazing job of certificating new pipeline infrastructure, from January 2000 to December 2014, there has been about 16,000 miles of new pipeline certificated and that would be about 118 total bcf a day of transport capacity. That's also a huge amount of additional infrastructure to move this gas throughout the country. So all of this to us, is a good news story.

Now when I look at marine LNG, and the possibilities for us, I see that as a new market for us. It's an opportunity. And we want to be able to take advantage of that new opportunity. I look at it a little bit as what's been going on in the last three or four years in the gas and electric discussions, and some of you may have been involved in that. But because of lower gas prices, and also some of the environmental regulations, our generators are increasingly turning to natural gas. And part of what we had in those discussions was something that John Graykowski talked about earlier in the marine side. We found that the power folks and the gas folks didn't really even speak the same language, so we had to sit down and talk and learn a little bit about each other's businesses. And because of those environmental regulations, we really needed to have those conversations. And I want to point out one thing. We are not criticizing diesel. We're not criticizing coal. We're not here to say you ought to shift, but if there are economic and environmental reasons that cause a shift to another fuel, we want the opportunity to be able to stand there and provide that fuel to you.

There was some discussion earlier about methane, and I'll just close with a couple of things on methane, and one comment about something that's sort of hanging out there on the horizon that gives me some pause. And I know not everybody can see this chart clearly, but just to sort of put this in perspective, I think you can see the broad parameters of this, and that big circle at the top is all of the greenhouse gas emissions.

And then the yellow is carbon dioxide, then there's methane and then in the really teeny tiny dot that's barely you can see in the middle is natural gas production contributions from methane. And we understand that methane is an issue. We understand that it is something we have to deal with. It is something that the gas industry is dealing with and if you look at the data, and I know there are lots of studies out there and the studies don't all disagree about the levels of methane. But I think in general, what you would find is that you'll see that methane emissions have been going down while natural gas production has been going up, and that's the good news story. And also as John said, we are incentivized to try to sell our methane. We'd rather sell it than have it escape into the atmosphere, in addition to the fact that we recognize the environmental dangers of having it escape into the atmosphere.

The final thing I want to talk about is infrastructure. We talked about it on the pipeline side. You talked about it on the infrastructure for building some of these export facilities, and John talked about the permitting that various sorts of facilities have to go through. There is currently CEQ policy guidance that was issued on December 24th, Christmas Eve -- Merry Christmas to all of us -- that if it's finalized, and it remains to be seen whether it will be finalized, directs all agencies that have NEPA or environmental assessment responsibility to take into account upstream and downstream impacts of the projects that they are reviewing. I'm a former FERC lawyer. For FERC, I find this policy guidance very troublesome, that you might have to take into account the impacts of Marcella shale production coming into a pipeline or how the gas would be used downstream of that pipeline. I'm concerned that this will put, stands the possibility of putting significant barriers in the way of infrastructure development and I think anybody in the gas industry or in any other industry for that matter, that has to go to an agency and go through NEFA review, needs to pay attention to this proposed policy guidance. Comments are due are March 25th and if I can stand on my bully pulpit for two seconds and encourage everyone to get involved in this discussion, I think that we got a lot to do to work on this. Charlie?

MR. EBINGER: Thank you very much Dena. Before turning to the floor, having listened to the last panel and the current panel, I just, and I ask this really out of ignorance, not as a comment, but it seems as if, at least a lot of the thrust at least in terms of what seems to be happening in the U.S. market and I was very interested to see what Wartsila was doing around the world. It seems as if a lot of the catalysts for greater LNG use has been in Jones Act tankers and I'm wondering, is that indeed the case or are there things we can also do to promote the use of gas that we'll use in our global maritime fleet? It's just a question to whoever would like to address it.

MR. HATLEY: I can speak a little bit on that. The Jones Act tankers, all of the ones under construction at this time and contracted, and there's more than a dozen, have all decided to go LNG ready, anticipating as John Graykowski had mentioned, that LNG will become available sometime in the near future. And I liken this to the business option, to never be dismissed. If you can have an option at low cost, take it, because the business window of opportunities may shift, and if LNG is available, make a rapid transformation at minimum cost to meet a new business need. And so by pre-planning at the construction phase and there's three ways they can do that, one is on paper with an approval, and two is on paper with an approval and some modest amount of infrastructure on the vessel, number three is deep investment, do everything and then wait for the fuel. Number one is being done the most, a little bit of number two, none of number three. So the industry is optioning when it's low cost, with maximum opportunity in the future to shift.

MR. SEMMES: I would add that the company that we've funded, called LNG America is talking with probably half a dozen international shipping fleets right now, some of which are public and some of which are not, so these companies, international companies are definitely looking at this, if this happens, that to date, the few announcements that have been made so far are vessels that will be built in the U.S. and will serve U.S. ports. But we hope and expect that this market is global, as you heard, and may end as more than just what we provided here.

MR. EBINGER: Okay, the floor is open for anyone that would like to ask a question. In the back there. We got both those.

MR. SALMON: Thank you. Scott Salmon with Shell. I know we talked a lot about the environmental policy being the number one driver in the price, but that's at the very highest level of you know, it's the public demanding certain things, price and clean environment. From a real world public policy perspective, I mean there are a lot of issues that are still out there, whether it's capital cost recovery, I think that was referenced in something, John, you talked about Canada last week. I think there's a question about simultaneous operations, whether you can load and unload cargoes and put fuel in vehicles that, or vessels, as they're in ships, or whether it's permitting new infrastructure. What recommendations does the panel have in terms of prioritizing these things? And the private sector may not be well equipped to do that but is there a government body that should be doing that or isn't doing it, to kind of bring it all together? Thanks.

MR. SEMMES: I'm not sure we would recommend a government agency to handle that. Sort of the way we look at it is, how do we -- we try to put ourselves in the customer's shoes and how do we make this very daily basic part of their business look at, from an LNG perspective, look just as it has from a diesel perspective, so on some of the issues you've raised in terms of -- a lot of these ships are used to refueling in the middle of the harbor for instance. So how do we serve vessels who aren't going to pull up to shore? So we may need a vessel to do that and you just saw an announcement that there was a bunkering vessel that will be built to serve, at least initially, the west coast and then Jacksonville. So I really don't think that the constraint here is going to be on the infrastructure side because these are all issues that are not I think too hard to overcome. The supply as I referenced, will be there in addition to Cheniere's project, there are two other world scale LNG projects in the Gulf coast that are starting construction and so I guess I would say, just making it easy on the customers as possible is really what our goal has been so far.

MR. HATLEY: I'd like to just add that to address the specific question on simultaneous operations as marine world has known for a long time with traditional fuels, Wartsila invited as guests, representatives of the United States Coast Guard and Transport Canada, to have week LNG immersion tour in May of 2014. They paid their way, we paid our way. There's nothing unusual about that, but we set it all up. They witnessed bunkering 359 of the Viking Brace in Stockholm Harbor. She came into the port at 6 A.M.; last line was at 9 A.M. In that 3 hour window the sea gas came onto the port corner of the vessel, unloaded the LNG while 2800 passengers disembarked and 2800 passengers embarked, while hundreds of cars and trucks went off and came on. Within a kilometer of the King's Castle in Sweden, Stockholm, bunkering 359. It can be done, with safe procedures, with priorities and training. These procedures are with upmost of safety in mind, with absolute training in a sense of every single person involved that we're doing this safely. And that dozens of experts, I can describe the trip later, but it was a weak version. And we think that helps the regulators understand on both sides of our North America's border, how it can be done correctly and safely.

MR. EBINGER: We had a question right there.

MR. ALAMEDA: Rob Alameda from gCaptain.com, a question for John Hatley. What were the first segments within the marine sector to adopt LNG as a fuel and why?

MR. HATLEY: You know Mike, could I stand when I answer? Because earlier we heard a little bit of a discussion on this and we talked about cargo loss, perhaps. There are two types of ships that rule -- volume limited ships and weight limited ships. That's your vertical access, traveling on two different types of routes -- world routes, global, or coastwise, maybe an eco-route. The basic distinction is that a volume limited ship may have a displacement of cargo or passengers. Weight limited ship certainly not, it weights out before it comes on line, just marks out. On world voyages, it's the problem of logistics on both ends of the ocean or however. On coastwise voyages, you're like a ping pong ball, several opportunities. So where is it going to be? Early, fast,

slow, last. Weight limited regional; volume limited regional, global weight limited, volume, global. Early, fast, slow, last. That's it, four segments.

MR. EBINGER: I think we have another question back over there?

MR. MOSSMAN: Hi, I'm Matt Mossman. I'm a freelance writer in town and my question is about pricing. I'd like to know what the prospects are for linking potential pricing to either Henry or crude prices or something else, and whether there's the domestic transportation industry, whether there's examples from the domestic transportation industry currently that can inform that?

MR. SEMMES: So our pricing structure that we're working off of is going to look at lot like our pricing structure for our export customers, so the price would be linked to the domestic price of gas, so a Henry hub which is sort of spot price for gas, with adders to reimburse the company for the cost of the infrastructure. And so the challenge there is, especially in today's market, and I'll give some numbers here, you need obviously to provide that price to the customer with a significant enough savings to essentially help them pay off the costs, the additional costs they've incurred to buy a ship that runs on LNG. So very simply, that's through the economics that these guys are running. So we look at the port of Houston. The port of Houston right now, it's called IMO 380, which is sort of your intermediate fuel oil, which is the dirty stuff that I talked about. You'd think of it in dollars per MMB to you and so that's about eight or nine dollars per MMB to you today, with oil prices at 50 dollars. The ultra-low sulphur diesel, they call it marine gas oil is closer to 16 dollars in MMB to you, so what you really need to do is offer the customer who now has had to switch from the eight dollar fuel to the 16 dollar fuel, a discount on the 16 dollar fuel, because otherwise, he'll say, well I'll just run on the 16 dollar fuel. And to give you some sense of a year ago, with before oil prices fell 50 percent, that that high priced fuel was above 20 dollars in MMB to you. So that was obviously a lot easier target for a bunker, a company that's providing bunker fuel to come in under. We still think there is a -- because Henry Hub is now $2.60, we still think you can come in and significantly under the $16.00 number I quoted, to provide that ship

owner with the savings if he needs to make that decision. But that's how we think about it.

MR. EBINGER: If I could play the devil's advocate for just a moment, and hit two issues that I wonder if you think they pose any threat to the LNG industry globally, moving forward. One is that, in a report Brookings did a couple years ago, we thought that companies like Cheniere that get into the market between now and 2020 will do very well, the time we wrote it because of the large arbitrage play between Asia and European prices, but we thought that after 2020, with all the gas projects coming in from Australia, maybe east Africa and early 2020's and others around the world, that there was the real prospect that the market could be oversupplied, so we came up with a rather pessimistic view of how many of the LNG projects currently before the government would actually ever be built, even if they were approved, whether they could be financed. Since that report came out, you know, we've seen a collapse of the LNG prices in the far east in particular, and I'm wondering, first question is, do we see any threat that LNG could get so available that at least in terms of thinking about export projects from the United States or Canada, that it might be a much shallower market than we had anticipated. And the second question, although I think it's very, I don't give much credence to it myself, but there are people on Wall Street who are beginning, because of climate change, to query, you know, whether all oil and gas companies, particularly producing companies, whether their reserves can ever be produced if we have any chance of holding to two degrees centigrade increase, and are beginning to devalue companies based on reserve estimates that would be much lower if that were indeed true and they could never produce this. And you also, on that same vein, you begin to see college endowments, and pension funds beginning to withdraw from fossil fuel company investments. I was wondering if any of those two things, you see any prospect pose dangers to the LNG market as we look out 10, 15 years.

MR. SEMMES: Oh definitely, I'd be happy to talk to this. It's funny because our CFO has, the first question is very relevant because he came over and said

the other day, please do some research for me, because this is the only question I'm getting when I go and speak to investors, really about the viability of LNG as an export, LNG exports post 2020 or whatever year you want to put on it. And what we've sort of -- I think what it comes down to one key issue, and you've already seen this happen, is that projects that aren't competitive from a cost perspective are falling away and will continue to fall away. You've seen that in western Canada. I think you will see that to some extent in Australia where comparable projects to ours are two, three, four times the price to build. So we believe and it's been fairly widely reported that U.S. projects are highly competitive from a cost perspective. Without getting too technical, we think about cost on dollars per ton of LNG, that capacity that you have. And so our plan in Louisiana is roughly around 500 dollars a ton and some of these more expensive projects that you're seeing fall away, they were well north of 1000 dollars a ton. So that said, Cheniere believes, I don't think Cheniere thinks that a lot of the projections for LNG exports from the United States by 2020, 2025, when you're getting into 15 bcf a day, we don't these are realistic, with the projects that are under construction today, clearly will be built and we think there are probably a few additional opportunities for other projects, just because of the situation in the commodity markets and the ability to finance them. Very quickly, to the second point, I think clearly we've talked about and the other panel talked about the environmental implications of LNG and the jury is still out, and but what I can say, from the research that we've done internally, is that, and there's a report out from the Department of Energy on this that looked at lifecycle costs, basically shipping LNG to Europe and to Asia to replace coal, and on a lifecycle basis, it was still a beneficial switch, taking into account emissions from the well head in the United States, to combustion in Europe and Asia. And I've traveled with the folks in our group who do a lot of the LNG marketing and this story is playing out all over the world, where really power generation is switching away from oil or from coal to gas. Chile is another good example, that has horrible problems with smog and sort of the more typical particulate matter because they got cut off from their gas supply. So they will be importing, and are

importing LNG already.

And look, even in the United States where we're making that next step to a much larger investment of renewables, a significant amount of very efficient combine cycle natural gas plants are going to be a part of that landscape to provide really what's sort of a flexible peaking mechanism, when, as the renewables fluctuate.

MR. EBINGER: Any more from the floor, unless somebody wanted to add anything?

MS. WIGGINS: I just wanted to add one point on that. And I agree with everything that Ben said, that we look at the export opportunities as sort of the flip side of the coin of the import terminals from a number of years ago, and if you saw the maps that were put out when we were all talking about import terminals, they sort of bring to the east coast and the gulf coast, and not many of those got built. And the market sorted it out. And I think in a similar vein, the market will sort out what is built on the export terminal side, and some of them will be built and will be viable and will go forward, and some of them will just fall off the drawing board and will not be built. And I agree with you that I don't think it's going to get to the export levels of some of the higher estimates of 15 bcf. I mean some people look at all the capabilities of all those projects and add the up and say that's what's going to be exported. And the studies that we've seen just don't support that. We think it will shake out somewhere in the eight bcf a day, maybe a little more, maybe a little less, but certainly not up in the 15 bcf a day range.

MR. EBINGER: Thank you. Rush in the back?

MR. ALAMEDA: Rob Alameda from gCaptain again. I've heard a little bit about infrastructures being one of the limiting factors to the use of LNG as a refuel. But you know, really, how much of an issue is it? If we're talking pipeline construction, I mean, that doesn't seem to be something we really need to be investing in considering it's -- you can't pipeline natural gas for a ship. It's got to go to a liquefaction plant, right, so can you tell me, tell us, what are some of the initial steps that would be required to make this more useful, I guess.

MS. WIGGINS: You got to get it to the liquefaction plant though.

MR. ALAMEDA: Of course, of course. But --

MS. WIGGINS: (laughter) That's pipeline.

MR. SEMMES: A very quick example from our plant, is about two hours' drive from Houston, in Louisiana, and so the trick or the challenge is to move the gas economically, the LNG, from the plant to the port of Houston and it's not based on the kind of complexity that's involved in our large LNG export facility, it's really not -- in my view, it's not a technical challenge or it's not an issue of complexity. It's the issue of doing that on a cost effective basis. So you could, you know, take six months and build a very complex expensive system to build a very expensive barge and shuttle to the Houston ship channel and unload and have all the sort of everything you could possibly want, but it may not be efficient, or it may not be efficient from a pricing perspective. And so whether that is, in the example of this facility in Jacksonville that's come up on line, they, excuse me -- it has not come on line yet -- they are initially trucking LNG from a plant in Alabama down to the coast and literally just trucking the LNG back and forth. And I would guess, I haven't seen the numbers, but I would guess that's not very cost effective for a long period of time, and they need this LNG liquefaction plant that they're building on site to sort of make the economics work. So the question isn't, is it possible. The question is, is it possible and are you still able to offer that attractive price to the customer in Jacksonville or in the Houston sub channel.

MR. ALAMEDA: Right, so are you -- are they getting natural gas at below 16 dollars per million btu in Jacksonville? I mean, that's the question, isn't it?

MR. SEMMES: Yes, exactly. And I would have to say, yes, but from what I've heard also, right, there's the additional issue that of the entire capacity of the LNG plant that they're building, only a fraction of that capacity is contracted at that price. And so, I'm almost certain that they're taking risk on a certain percentage of that plant that other people come -- other customers come up and agree to take that deal. So I think the answer is yes, but will customers come up and patronize the facility.

MR. ALAMEDA: Can you provide a little bit more detail on what the Cheniere is investing in in the port of Houston?

MR. SEMMES: Yep, we made a significant investment, small investment as part of our entire portfolio, in a company that is trying to solve that problem, and so whether that takes the form of at least initially similar to Jacksonville, trucks, bringing LNG to the port of Houston, I think ultimately as demand develops, that probably takes the form of a larger bunker vessel that looks something like the vessel that will be servicing the west coast, and so that -- this startup company is right in the middle of making those decisions as we speak. And then building, essentially building a small depot in the port of Houston to serve the demand.

DR. EBINGER: If you all had to pick one or two issues or actions by the federal government that might accelerate the use of LNG, what would they be? Anybody?

MS. WIGGINS: Go ahead.

MR. SEMMES: Very quickly, I talked about this with a panelist earlier. The enforcement of the regulations that came into effect on January 1, so in our view, that is one of the most critical pieces to this whole puzzle and that last couple of weekends ago, I was out on the weekend looking out on the water and near the port of Houston, Galveston Bay, and some of the biggest ships in the world are coming in and out of this port. These are Afromax, huge oil tankers, and sort of looking up at them. You know, there's smoke coming out of the smoke stack, it looks pretty brown. They're in the 200 miles of the coast. Are they -- who knows -- are they violating these new regulations or not? And it's pretty difficult to determine, because I think you literally need to bore the ship and test those emissions. So there's a lot of complexity there, how the EPA is going to work with the Coast Guard and we would obviously love to see those regulations strongly enforced.

MS. WIGGINS: It seems like to me and this is something I've learned from listening to others on the panel, that as Ben was saying, it's the regulatory structure

that needs in part to be straightened out, to understand if you want to engage in this kind of operation, who does what, who's got the authority and what the limits of that authority and who you have to go to get the kind of permitting you need and how does it fit together with EPA and maybe FERC's got a role in it, and the Coast Guard and just understanding how that all goes together, and there was some question earlier about whether federal legislation is needed to effectuate that. I'm interested in learning more about that. Again, it's a market opportunity for us. We want the market rules to work and to facilitate getting these projects off the ground.

MR. HATLEY: First, I agree with what you said because I think John Graykowski said we could learn a lot from Europe's focus on driving forward in a positive way instead of having a quagmire to get sorted out. But I think of a very pragmatic thing right now. Congressman Young from Indiana is going to propose a bill to remove an unfortunate bias against LNG fuel. Today LNG fuel is taxed on a gallon basis as is diesel fuel. However, that's unfair and biased because LNG has a lot less calorific energy content in a gallon than a gallon of diesel fuel. So we're taxed at 1.7 times higher on an energy basis. To be fair, that's got to get removed. I urge any of you to contact your Congressmen and or Congressman Young about this issue. Why have a burden on a good thing? That's unintended. It's stupid.

MR. EBINGER: John, you made a compelling case about the EU and all the nations agreeing to utilize more LNG, but as I understand it the reality is the LNG capacity in Europe is at the liquefaction facilities, is marginal, maybe under 10 percent. Why is it that if they have this liquefaction capability, why is Europe not using more LNG and is reverting back in many cases to burning dirty coal?

MR. HATLEY: Can I take two minutes? That's a great question?

MR. EBINGER: How about one minute, 30 seconds?

MR. HATLEY: Sure.

MR. EBINGER: Go ahead.

MR. HATLEY: Okay. Compare and contrast, Europe. In Europe, fuels

are more on an energy parity basis, so LNG does not have the deep discount, relatively speaking, you find in the Americas. But in Europe, it's government created pressure points in the market that are helping it go forward, such as incentives in Norway to avoid a tax, incentives in Norway to help pay your CAPEX or OPEX costs to going to LNG. So in Europe, where Wartsila's headquartered, we will find many more scrubbers employed. Contrast at the U.S., everything's opposite. We have a deep differential on the fuel price and seem to have for, if not decades, maybe more than a century going out. Because of that, extreme opportunity on the economics and the blessings of the environmental, we may not need the same emphasis of governmental urging the market to move with different subsidies or different fines. So I think that's a profound difference. And that's how we see more scrubbers for Europe and much more LNG for transportation here. We sell both.

MR. EBINGER: Anybody else from the floor? Yes sir.

MR. ENG: Hello, good morning. My name is Jason Eng; I'm a student from SEIS. My question is, to what extent do you think this push into LNG bunkering being hampered by the fact that there is not a global market for natural gas, because it's still very regional. I can see there's a lot of potential in terms of the pricing, some of the speakers have mentioned using a Henry Hub, but in Asia, there isn't really a spot market for natural gas, so I think that there will be some difficulties in conversion to LNG in Asia, at the very least. But that's where a lot of activity and shipping's happening.

MR. HATLEY: I don't know if you saw me when I stood up and my mike almost pulled me back. That horizontal line -- oceans, most wise, oceans, as you said, difficulty to get all the bunkering set in place. You'll find that much more on the regional side where it may or may not be in INICA because you're going back and forth several times, and one relocation with opportunities frequently, to maybe bunker at the same place. Early, fast, we're all on that side. Slow, last, we're on this side.

MR. SEMMES: I would add that I think this is an area that gets us much more optimistic about bunkering in the United States. To your point, a very regional

fragmented market, we actually have, I've spoken with customers, who haven't -- they haven't decided to do this yet, but actually were considering shuttling a vessel from Europe to the -- sounds crazy but to the United States, to pick up very inexpensive LNG, bring it back to Europe and use it as a shipping fuel. So we certainly have customers who will likely make runs, Europe to the United States, and then may sort of tack on a trip down to the Gulf Coast because they can pick up additional product there and at the same time, refuel with a U.S. linked gas price. And so, I think you'll see these trade routes start to be configured, if it's possible for these companies to make a journey and at least fuel on one or both legs in the United States to take advantage of that low gas price, and then potentially be forced to eat a higher cost on Asia or wherever their other side of.

MR. EBINGER: Go ahead, Jason.

MR. TOM: Yeah, Jason Tom, Coast Guard Fellow here at Brookings. My question for the panel is, we talked a little bit about federal government, from a regulatory standpoint, and the last panel hinted that states will be an issue as well. And I guess my question is, are there any states that you would see as out in front in terms of best practices, in terms of taking a strategic view for facilitating this type of development and perhaps also on the environmental side as well. Thank you.

MR. SEMMES: It's a great question. Unfortunately, it's a little bit too early to tell. And so the states to some extent are sort of a grab bag of regulations that govern bunkering at U.S. ports, but I think to the point that a lot of the other panelists made, they didn't really contemplate LNG bunkering and are only starting to incorporate that into the regulations. So you have a situation where the -- essentially the EPA, the federal government has said, these are the new fuel standards. This is the enforcement regime. Figure out how to deal with that and we've, for our company specifically, have had talks with the port of Houston, clearly, and other, as well as all the regulatory agencies that would impact our ability to run an LNG bunkering operation in Texas. I can't speak for other states unfortunately. I did hear that New York State just came out with a -- this was an LNG fueling, so not specifically bunkering regulations. So they're

gradually starting to come to -- to develop this legislation, but it's been pretty slow to develop so far.

MR. EBINGER: My only quick suggestion, because I'm not an expert on the states and the regulatory environments, however I would say look to Louisiana, Port Fourchon this year, the Harvey Gulf fueling facility will be (inaudible) understanding that Louisiana embraces oil and gas jobs, but there are several issues that they worked through to allow that to transpire this year. So I think that would be an interesting model to look at.

MS. WIGGINS: I also think that it's up to our industry to try to engage on the state and local level. We have, at least on the federal level here recently, at the Federal Energy Regulatory Commission, seen protestors literally lying in the streets protesting the various and assorted infrastructure projects and I don't know what the ultimate answer to it is on how do we address that, but I think people in local communities have some legitimate questions that they ask about infrastructure projects and I think we in the industry do ourselves a disservice when we sort of put our heads in the sand and try to ignore those. I think we've got to engage.

MR. TOM: I would just add too very quickly, that the sort of the shipping regulations are very tightly controlled by ABS and DNV, these are the agencies that work closely with the Coast Guard, so I think from that perspective they will, at least on the shipping side, be able to handle some of these issues as they crop up.

MR. EBINGER: John, I was wondering, just looking internationally for a moment, if you could give us any insights as one of the largest natural gas producers in the world, what Russia is doing with looking at LNG for marine transportation, and also in some of the major ship building areas, like South Korea, Singapore, Finland. Is there an active move to be constructing a lot of LNG based vessels, if you have any insights on that?

MR. HATLEY: A little over a year ago, our company asked me to go to China and I did. There's tremendous opportunities, just huge for coastal and rivers,

marine transportation, and a real drive amongst the public to clean up the dirty air. In Beijing, it's just horrifically bad, even in Shanghai. In Europe, there's a very very strong move in the wealth public, reflected by the politicians to really really continue to clean up, not only the northern Baltic, which has the first SECA, but will soon see the Mediterranean. And then you go to the other rich nations, Japan and Australia, will have more ECA SECA's there as well. And then the rest of the Caribbean I'm sure is not far behind. So I think that, not having been to Russia, I can't comment on that part of the equation, I think that for China, very, very, very strong.

MR. EBINGER: We have time for one or two more questions, if they're short, if anybody has any from the floor? Well, if not -- ah -- one back.

SPEAKER: How likely are we going to see floating storage, floating LNG storage in the United States, either in Gulf of Mexico or off the U.S. east coast or west coast for that matter -- storage and offloading?

MR. SEMMES: I think, very likely. There is -- a lot of these technologies, or these technologies exist and they're being deployed around the world. There's a proposal to do a floating storage and re-gasification in a unit off the coast of Puerto Rico. So we keep pretty close tabs on these obviously. They're potentially competitors. If you can tie either an LNG storage, floating storage and moor that to the coast line, some of these technologies have liquefaction built in, so there is a ship that's being built, called the Prelude, which has these technologies. One thing that gives us comfort is, at least today, they're very very expensive. But just a storage, floating storage, would not be that expensive. I think it's probably more likely to see technologies that have, that incorporate these, either these other components, liquefaction or re-gasification as well. There's a lot of gas storage in the United States. The need for that is questionable.

MR. EBINGER: Well if you'd all please join me in thanking the panelists for a very interesting presentation. (applause) Thank you all very much.

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I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

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