Liquefied Natural Gas (LNG) Research and Development (R&D) Public Meeting and Forum

November 15, 2022

(This transcript of the LNG Forum presentations contains minor edits for clarity and grammar. Questions and answer sessions were not included due to inaudible issues and because clarifications to incomplete questions could not be made)

9:00 a.m. Good Morning/Welcome
Event Moderator: Robert Smith, R&D Program Manager, DOT/PHMSA

Smith, Robert (PHMSA)

Good morning and welcome to the Pipeline and Hazardous Materials Safety Administration liquefied natural gas research and development public meeting and forum. My name is Robert Smith, and I'm the Research Program Manager for PHMSA's Office of Pipeline Safety. I'll be serving as your master of ceremonies for today. We want to thank you all for your attendance and participation with the special thanks to our presenters, moderators, and working group leaders for the job that they're going to do over the next two days.

Your experience at this virtual event is very important to PHMSA. That said, let me call your attention to a few housekeeping items. General attendees will remain on mute and off camera; only moderator speakers and presenters will be unmuted during their participation on the morning's agenda. Panel moderators and presenters are welcome to briefly use their camera during introductions but should turn them off during the actual presentation and turn them on again during panel Q&A.

We intend to adhere to the morning agenda, but we'll adjust the times as needed. These proceedings will have a transcript, which I just started. The transcript will be available on the meeting website soon after the event. PHMSA will also post to the meeting website all presentation files shortly after the event for your information.

You are welcome to submit questions to the panel moderator during the planned Q&A period after each panel. Please use the Teams feature entitled "Chat." Be sure to specify if the question is for the entire panel or for the particular panelist.

And, with that, let's move to our first agenda item. It's now my pleasure to introduce Tristan Brown, PHMSA's Deputy Administrator. Tristan, please proceed with your opening remarks.

9:05 a.m. Opening Remarks by the PHMSA Deputy Administrator – Tristan Brown

Brown, Tristan (PHMSA)

Great. Good morning and thank you so much, Robert, and thank you so much to the PHMSA team members and colleagues who put together this tremendous two-day event. Thanks again to

all the hundreds of registrants from the private sector and the public sector and our collaborative state agencies.

I am really excited about what we may accomplish in the next couple days. Most of you are probably aware that at PHMSA we oversee the safe transportation of hazardous materials through pipelines and other modes of transportation, including planes, trains, automobiles, and trucks. And, in that vein, we actually oversee the safe design, operation, and maintenance of nearly 3.3 million miles of pipeline facilities, oil, gas, and other hazardous materials.

And, on the HAZMAT side, we oversee nearly one in ten goods that are transported in the U.S. That's a heavy workload, and it's only getting heavier. The transportation of energy products that PHMSA regulates is expanding in scope due in part to the increase of LNG exports over the last decade. The Energy Information Administration clocks export capacity at almost 11 billion cubic feet per day. That's up from 2015, where it was only 1 billion. In 2021, we had record highs of nearly 3 1/2 billion cubic feet per day exported to 45 countries and 54% of total U.S. natural gas was exported. We collaborate with our federal, state, and local agencies in reviewing the design, construction, operation, maintenance, and inspection of pipeline facilities, including over 160 LNG facilities. We maintain coalitions with stakeholders participating in standard setting committees, providing comments on new emerging practices and technologies, educating the public, and developing regulations and standards.

But, in the age of data that we're living in, we can see that achieving a sufficient level of safety, environmental protection, and efficiency requires adequate investments to identify and mitigate risks to energy production and transportation. This is especially important to prevent failures that we've seen in recent years. Our pipeline safety research program works with academia, government agencies, and industry to sponsor our projects that focus on improving safety and then reducing environmental impacts and enhancing reliability and efficiency.

Through this, we focus on investments that promote safety, environment protection, and, in particular, climate change mitigation and using transportation infrastructure as an engine for equity. So, one example of this is the use of software models for modeling vapor cloud explosions, which we've been reviewing as part of our update to our LNG facilities regulations, LNG facilities, and update rule. Congress has expressed interest in establishing an LNG Center of excellence under PHMSA and under our umbrella of activities. So, we are currently finalizing a report to Congress on the subject, which contemplates future activities like we're undertaking today and tomorrow to foster improved collaboration between stakeholders across the sector to achieve our common goals.

This forum provides an opportunity for stakeholders to review our research and what we've conducted in the last few years, and then to help us identify gaps that may exist specifically in areas related to siding design, construction, fire protection, operations, and maintenance; the gaps you identify will inform our future work and have a real-world impact both on safety and people, but also the environment, climate change, and truly providing benefits to the nation and the world.

In addition to sparking what we hope is a lively exchange of ideas, we're also hopeful this forum will help inform our LNG related research agenda. And, as an update for those tracking the Freeport LNG facility incident from earlier this year, we're hoping to get a preliminary copy of

the root cause failure analysis up on our website as soon as today. It's a preliminary copy. We have got to have our attorneys go through the redacted material provided to us in anticipation of posting it to the public, but we want to get that out to folks and to the public as soon as possible. We look forward to discussing these findings with stakeholders that are on here over the next few days, so I want to get to all the meat and substance of the next few days. Thank you, Robert and the whole PHMSA team and everybody who's participating and contributing to the really important work that we are going to cover in the next few days.

Thank you so much and we look forward to the discussions.

9:10 a.m. Opening Remarks by Director of Engineering and Research – Sentho

Smith, Robert (PHMSA)

Tristan, thank you very much for those opening remarks. And, with that, let's move to our next agenda item, which is with Sentho White, Director of Engineering and Research Division within PHMSA's Office of Pipeline Safety, to provide a brief overview about our research program and focus on LNG facility challenges. Sentho, over to you, but let me please bring up your presentation first.

White, Sentho (PHMSA)

Alright, great. Thanks Bob. And, again, thanks Bob for overseeing this event and good morning, everybody. Again, welcome to the first day of our R&D LNG Forum, next slide. As Bob mentioned, I'm Sentho White, the Director of the Engineering and Research Division in PHMSA's Office of Pipeline Safety. I'd like to take this opportunity on behalf of PHMSA to say that we appreciate your interest in today's meeting and look forward to your participation in the upcoming working groups that will be taking place this afternoon and tomorrow. I believe this is actually our first ever LNG focused R&D forum. So, I'm definitely looking forward to all the collaboration that will be happening today and tomorrow. It's at events such as this one where we can collaborate with stakeholders and hear different perspectives from federal agencies and state partners, public interest groups, research organizations, academia, and industry on very important safety risks and challenges for LNG facilities. And these forums really help PHMSA identify technical gaps that inform PHMSA's agenda for future research investments.

Next slide, please. And one more. So, the department's research programs, including PHMSA's safety research program, are really instrumental in advancing innovation and technologies to provide safe and equitable solutions that benefit the public federal research programs and, not only help inform decision makers with knowledge and data on important policies, but also help support the development and deployment of innovative technologies to advance public safety. And PHMSA's research program sponsors projects focused on providing near-term solutions for the nation's pipelines transportation system and LNG and underground natural gas storage facilities that improve safety, reduce environmental impact, and enhance reliability. This also includes the commitment to the administration's policies and priorities through R&D investments that promote safety and environmental protection solutions that confront the climate crisis, and economic and equitable solutions to advance LNG transportation.

Next slide please. And, so, as you see here in this next slide, PHMSA's program is really

comprehensive in its research strategy and awards research through four subprograms, leveraging public and private partnerships as shown here. So, starting at the top of the slide and working your way down, the first is really showcasing PHMSA's university research program, known as the Competitive Academic Agreement Program or "CAAP;" and CAAP was established in 2013, and it allows PHMSA to partner with universities to fund basic research that is focused on those high risk, high payoff solutions. CAAP also exposes students to subject matter that is common to pipeline safety, LNG, underground gas storage, engineering topics, and really encourages career placement within the industry, as well as the federal government. Today, there have been over 360 students that have participated in our CAAP research and approximately $20 million has been awarded to universities.

The research outcomes from CAAP are intended to be handed off to either the department, small business, Innovative Research Program, or through follow-up research that can be performed through business core program to develop more mature research and technology development and deployment. We also collaborate with several federal agencies, including Sandia, National Energy Technology Laboratory (NETL), and others on pipeline safety research projects.

Next slide. So, we've had a great track record in strong performance on technology development and deployment into commercial applications. And, as you can see here, you know our program frequently has tech demonstrations and patent activities with the awarded research. And, since 2002, there have been 77 projects that have resulted in tech demonstrations, as well as 35 commercialized technologies and 22 patents that have been granted which have stemmed from our R&D investments. Most of our areas of success have been in pipeline threat prevention, leak detection and anomaly detection. As we expand our LNG research portfolio in the future, we hope to see technology solutions that address LNG facility challenges.

Next slide. Our R&D program goals also generate and promote knowledge for its stakeholders, research project final reports, as well as conference and journal publications that are used to inform decision making which can improve safety performance. PHMSA's website has a library of research topics, papers, and publications that are available with sortable features for you to find various topics on pipeline safety; and, to date, since 2008 when we began tracking these metrics, the R&D portal has had over 42 million visits and over 2,000,000 R&D files that have been downloaded.

Next slide. So, these next few slides provide a historical perspective and a present-day outlook on the LNG safety challenges. Though LNG uses dates back to the 1900s, where it was first patented for handling and shipping in 1914, the first commercial LNG facilities in the United States were constructed in the early 1940s in West Virginia and Ohio, and specifically the first LNG peak shaving facility was constructed in 1941 in Cleveland, Ohio, by East Ohio Gas Company in 1944. This facility experienced the worst major LNG disaster in history. One of the facility storage tanks ruptured, releasing the entire contents of LNG into adjacent streets and sewer systems. The LNG vaporized and migrated into the city sewers and ignited; and, because it was confined, it caused multiple explosions. This unfortunate disaster resulted in 130 deaths, hundreds of injuries, and over $7 million in property damage. The cause was due to substandard World War II rationed steel that became brittle on contact with the extreme cold temperatures of LNG.

Current regulatory requirements now ensure that proper materials suited for cryogenic

temperatures are used and that impounded systems are designed and constructed properly to contain a release of LNG at the site. Since about 15 years after the Cleveland, Ohio, incident – beginning in the 1960s and early ‘70s – the number of LNG facilities in the United States has increased dramatically. However, LNG demand waned during the 1980s; but, over the last several years, as Tristan mentioned, the market has shifted towards LNG exports, with several new or existing facilities either constructed, under construction, or planned for construction.

Next slide. This slide illustrates the dramatic increase in the number of LNG import facilities about 15 years after the Cleveland, Ohio incident in the 1960s and early ‘70s that were due to domestic gas shortages. The interest in LNG continued to decline in the 1980s; but, over the past few years, it has increased again with several new facilities that are being used or will be used for export operations.

Next slide. It wasn't until October 1972 when DOT incorporated the 1971 edition of National Fire Protection Association (NFPA) 59A as interim federal safety standards for LNG facilities; and, from 1977 to about 1979, DOT proceeded with rulemaking to establish permanent federal safety standards for LNG facilities. These regulations were developed in 1980 for the types of LNG storage facilities in use at the time to repeat shaving facilities, marine import terminals, and mobile and temporary facilities.

Next slide. With the increase in domestic natural gas supplies from shale across the country and stricter greenhouse gas emission regulations, the U.S. has seen an increase in LNG transportation modes. And, while PHMSA regulates LNG facilities that are connected to a Part 192 natural gas pipeline, LNG transportation by truck, rail, marine, bunker buses, and ferries is becoming increasingly prevalent. And, while many of these transportation modes for LNG may not fall under the jurisdiction of PHMSA, comparable safety challenges may exist and the need for research investments to provide solutions is critical to address LNG safety gaps.

Next slide. So, this slide illustrates the size comparison between a typical marine export terminal. A peak shaver, which is the middle yellow box, and a small-scale facility, which of course is a smallest box in yellow. These are facilities, such as being used for vehicle refueling stations. And, so, with the emergence of LNG export facilities and other types of LNG facilities, the risk profile is changing based on the footprint and location of these facilities.

Next slide. This slide illustrates the number and locations of LNG facilities across the U.S. There are more than 168 LNG facilities operating in the U.S., including 13 import and export terminals, 70 peak shaving facilities, and the remaining facilities being satellite and mobile or temporary facilities.

Next slide. So, in the next few slides, I'll provide PHMSA’s historical investments in LNG safety. And, although PHMSA has only recently begun investing in LNG research, this focused area and portfolio of LNG projects will continue to expand. Today, PHMSA has invested in 14 projects, totaling $5.7 million in federal funding. Project information and publicly available reports are available through the provided link on the slide, and these projects will be further discussed in the working groups this afternoon. PHMSA has also invested in government funded research with Sandia National Labs, and one of the research projects from Sandia will be presented later this afternoon in working Group 2 for facility siting; so, stay tuned to that.

Next slide. The figures illustrated here in this slide highlight some of our ongoing four LNG knowledge-based research projects that were identified as research safety gaps that were discussed and identified during the February 2020 R&D Forum; and, again, these projects are going to be discussed in further detail in the working groups later on today.

Next slide. Though our program is focused on a few things, one is producing outputs of informative research solutions, and also driving desired outcomes of new knowledge to inform nationally recognized consensus standards and regulatory policy and contributing towards impacting other PHMSA programs and initiatives that ultimately advance our safety mission.

Next slide. Here are a few of our important links to our R&D program. We believe that our program web pages provide transparency into our activities, inform our stakeholders, and showcase our R&D portfolio. So, here are just a few links that can be accessed through the PHMSA main research page. And, in particular, I encourage you to join our program alerts distribution list, so you won't ever miss out on an opportunity or news about our R&D program.

And with that, that concludes my presentation. I'd like to of course thank you, the folks in the R&D and the LNG teams; without the great work that you guys have done to organize this event, we would never be able to accomplish this. I'd also like to thank our panel participants, who you will hear from next – the working group leaders – and really, all of you who plan to participate this afternoon and tomorrow. So, on behalf of the R&D Team, thank you for your time and I will hand the mic over to our MC, Robert Smith.

Smith, Robert (PHMSA)

Great and thank you, Sentho.

9:30 a.m. Public Interest/Advocacy Discussion
Panel Moderator: Sentho White, Dir., Engineering and Research Div., DOT/PHMSA

Smith, Robert (PHMSA)

I'm sorry, we did not plan any questions and answers after the first couple presentations this morning. So, let's transition to our first panel and we will have some questions and answers after that, that is for public interest and advocacy. So, panelists, please be ready to unmute yourself when called upon. Let me now reintroduce Sentho White, who will moderate this first panel discussion and the following Q&A session. As a reminder, please type your questions into the Teams “Chat” feature. So, Sentho...

White, Sentho (PHMSA)

Alright. Thanks, Bob, and good morning again and we appreciate everyone's participation, especially our presenters to discuss LNG facility challenges and help generate input into PHMSA's future research agenda. And, I have the pleasure of moderating the first panel and the objective is for our panelists to provide their organization’s perspective with LNG facilities and really generate a good discussion on how our R&D program can further advance safety and

environmental protection. So, I am pleased to introduce our first presenter, Bill Karam, Executive Director of the Pipeline Safety Trust, and Steven Hamburg, Chief Scientist with the Environmental Defense Fund. Bill will be presenting first on the Pipeline Safety Trust perspective. And, so, with that, over to you, Bill.

Bill Karam

Thank you, Sentho. My name is Bill Karam, and I am the Executive Director of the Pipeline Safety Trust. I want to just start off, in case there was any doubt, I am not an engineer, and I am not a scientist.

So, really, why I am here is to just bring the public perspective to the discussion and remind everyone what's at stake. I think we all understand the potential, given the energy density involved in LNG. So, with that in mind, I just want to give a little history of the pipeline safety trust and how it was formed.

Robert, if you would, go to the next slide. So, we were formed in the aftermath of a pipeline tragedy. A quarter million gallons of gasoline ruptured from a refined products line and spilled into a creek that runs through the middle of our town, and it ignited and killed three boys. It has become a watershed moment in pipeline safety, for the industry, for the public, and for the regulators. We were formed as a watchdog on the pipeline industry and the regulators out of that tragedy. We really serve as the only national nonprofit working on pipeline safety.

Next slide please. So, our mission is to promote pipeline safety through education and advocacy, increased access to information, and partnerships with resident safety advocates, government, and industry, resulting in safer communities and a healthier environment.

Next slide. When you look at our mission versus PHMSA's mission, there is a lot of overlap; and, so, we all, of course share the goals of safer pipelines with zero incidents. Really, any stakeholder in pipeline safety, whether it be tribes, as rights holders, or the industry, or, of course, other public, we all share this overlap on our priorities and goals of zero incidents.

Next slide. So, the Pipeline Safety Trust really has not had the capacity to engage in LNG. We certainly recognize the severe safety risks and the contributions to greenhouse gas emissions posed by LNG. But, being such a small organization, the pure pipelines have kept us so busy. However, we're at a place where we've had a bit of expansion in staff, and also LNG is becoming more and more important, and the regulations are becoming more and more outdated; it is becoming a higher priority. So, we are starting to get up to speed as much as we can. I think seeing things like these vapor cloud explosions and the potential they have to the communities around them was certainly eye opening to us. Also, with these announced expansions and construction, we are looking at the Environmental Integrity Project. It is estimated that LNG facilities could emit 90 million tons of greenhouse gas per year, and that's ignoring upstream and downstream. So, from community safety, public safety, and climate change, LNG is becoming a larger and larger priority.

Next slide please. So, we went into the data because the facility numbers are limited. These incident numbers are limited, but I think we need to remember how catastrophic an incident can

be; and, we really do have this goal of zero incidents. So, we just looked at number of incidents reported over the years. We do see an increased trend here.
Next slide. Here, it's breaking them down between whether they were significant incidents or not, and there's an upward trend on both significant and not significant.

Next slide. This is looking at the amount of a product released – of methane released, also an upward trend.

Next slide. This is looking at average per incident also going up. The last chart I have here is next. We see a very large incident of release back in 2014, and that was a Newport incident operated by Williams, it kind of distorts the trend on the rest of the releases.

Next slide. So, as I mentioned before, LNG is starting to become a bigger priority for the Trust, and, as Sentho mentioned, a lot of that is due to the transition over to the export terminals. You know, we really went from zero exported LNG in 2015 to becoming one of the largest exporters in the world in a very short amount of time. The regulations have not caught up, and there are knowledge gaps as well. I'm really happy to see that PHMSA has a dedicated R&D Forum today to address some of those knowledge gaps, because we really do believe that this rapid growth will have a significant safety and environmental impact and we need to stay ahead of it.

Next slide. So, again, I am not an engineer, and not a scientist. In preparation for this, I tried to reach out to some stakeholders in the public who have a little more knowledge around the technical side of this than me and ask about the kinds of knowledge gaps they had identified. A big one that came up from multiple folks is this flex model and its questionable fitness for determining explosion over pressure. This is an example showing that it does not accurately predict anywhere near what the explosion overpressure would be. So, looking at that, the modeling to determine exclusion zones, obviously siting is an incredibly important safety issue when talking about LNG and making sure that we are properly modeling for export facilities and all the extra pieces that come with that. Then, this is something that I bring up. On any R&D question, in addition to the very technical engineering side, which of course is incredibly important, we believe that PHMSA's R&D should also be funding more social science around communicating risk. Very few organizations or people communicate risk well, and where there is a lot of knowledge gaps around how to communicate risk well to people, especially when we're talking about things like this, where incidents maybe don't happen quite as often, but, when they do, they can be so catastrophic. It is hard to communicate that risk to people, and we think that there should be some money dedicated there.

The final slide is my contact information. I'm always available to talk to anybody. Reach out anytime.

Please, I'm in learn mode, so, if I get anything wrong, please point it out to me, or, if you'd like to hear the public's perspective on anything, I'm always available. Thank you Sentho.

White, Sentho (PHMSA)

Thank you, Bill, for sharing that interesting perspective and I'm going to now turn it over to our next presenter, Steven Hamburg, Chief Scientist with the EDF.

9:30 a.m. Public Interest/Advocacy Discussion (Continued)
Panel Moderator: Sentho White, Dir., Engineering and Research Div., DOT/PHMSA

- Environmental Defense Fund: Steven Hamburg, Chief Scientist

Steven Hamburg

Great. Thanks so much, Sentho, and it's great to be here. I just want to reiterate what Bill said. I think that we need to think about LNG and the context. Obviously, safety is a critically important element, but also environment and the two go hand-in-hand because usually the safety issues arise from loss of product. I would endorse his last comment – just that we really do need more social science understanding, because there are a lot of us, I think – most of the folks on the call – who recognize a lot of misunderstanding about LNG and just what it is, what it isn't, and the safety and environmental implications thereof. And, obviously, LNG is playing an incredibly important role in society for a whole host of reasons. So, it's an integral part of the energy scene, and we need to get it right. Next slide please.

As we think about that, I am going to show a series of graphics from different papers, recent papers. We really need to think about LNG. While responsibility may be among different agencies, depending on which portion of the value chain one is looking at, we really have to think about LNG in its entire value chain and how it fits together, because we can't segment it, or we really risk misunderstanding the implications from an environmental standpoint. So, what I'm going to try and do is just talk briefly about some of the issues related to doing that well. It is still really very early days. We have very limited data, very little scientific literature on these issues and we really need to rapidly increase that so that we really can understand and maximize the benefits and minimize any negative implications from using LNG.

Next slide, please. If we think about the environmental impacts of LNG, I'd put it into sort of three basic categories. I'm going to talk about the middle one, mainly. So, we have a mission associated simply with the production and handling of LNG, which are beyond those that are greenhouse gases. Then, we, of course, have the greenhouse gas implications. As Bill described, we need to think about those, as they can be quite significant. Then, embodied energy. It takes a lot of energy to produce LNG and we really understand what those implications are. Again, these are value neutral. They're just trying to really drive having more data to be able to make effective decisions in ways that really meet the objectives which society might have, whoever is involved.

Next slide, please. So, the first one I want to raise is this whole issue of boundary conditions. What do I mean by that? It's what is and isn't included when we do an analysis. If we look at the literature so far – and not restricted to LNG, but in general – the type of analysis that we see is where you draw those conditions, what's in and what's out has a dramatic impact on what your conclusions are; and what we often don't do is actually test the assumptions of our boundary conditions and whether our conclusions change. That really has to be the key test, if we make it larger or smaller, does that affect what we conclude? If it does, then we have to be really crystal clear about how our assumptions are driving our conclusions. And this is really an element that does not get nearly enough attention. The spatial domain really matters. Are you talking about a

segment of the value chain or the full value chain? Are you working on single operating conditions or diverse operating conditions?

Because, seldom, particularly in LNG, it's not a constant that you're going to be producing. You're not. It's not a constant system that's on and off, and that really makes a big difference. And I'll come back to it. Then, the timeframe as we think about it with respect to greenhouse gases. I'll talk about the metrics themselves, but over what time are we concerned? Are we solving a 100-year problem, a 20-year problem, a 50-year problem, a 1,000-year problem? And it actually turns out, that matters. Then, in turn, what metrics are we using? Relative to being able to do this kind of analysis, whether it's through life cycle analysis or not, we do have to be thinking about the metrics, because that does make an enormous difference, both temporally and the dynamics. And, of course, the timeframe.

Next slide please. Sorry, just if you can go back one, the emphasis I want to make is that the timeframe should really align with policy objectives. The key here is that there is no proper single right scientific timeframe. Are we doing our analysis, thinking about 20-year impacts, 50-year impacts? I've highlighted this because we often use, and I'll come back to this, the CO_2e 100-year timeframe by default because it was established in the Kyoto Protocol. However, in fact, we often have policy objectives, as we do in the United States that are much shorter term. And, if we do it over 100 years or over a shorter time, we get quite a different effect on the environment; on the climate. So, there's not a right or wrong answer, but we have to make sure that we're doing an analysis aligned with what our objectives are, our policy objectives, because it does matter.

Next slide please. So, this is just from a study that University of West Virginia carried out on LNG trucks. It's not directly germane to the conversation today, but it is in the sense of the study boundaries, thinking about what's in and what's out. This was the first study to really look at emissions from the LNG value chain, associated with long-haul trucking, primarily. And the interesting thing here is, if you put that together, it's a lot harder to do than one might think, because your production areas where you are getting it from will matter. And, in addition, how you actually deal with the trucks and the fueling stations has a big impact on where you draw the line. So, is it just the fueling station or is it actually when the truck is on the road? It turns out, for understanding this particular problem, it makes an enormous difference, because the fueling station isn't the only place that fuel is actually vented.

In this case, LNG boils off and when you include it outside of the boundary of the fuel station during operation, you get a very different answer than if you just deal with it in the fueling station. Again, not right or wrong, but it's very different and you can easily get a spurious inference if you don't look at it in its entirety.

Next slide, please. This figure, which came out of the paper by Clark Adal, did not include that operation outside and, again, it's correct, but it misses a very large source of emissions associated with preventive with blowdown from the trucks prior to arriving at the station, which accelerates their ability to refuel quickly. So, again, the boundary conditions matter.

Next slide please. So, then we can look at a recent paper looking at the whole processing of LNG, the production and the different elements, again, where we are thinking about where it is coming from. In this case, it's the work that was done focused on Cheniere and really looking at

the full system, which is great. But, again, where we draw the boundaries, and I'm going to particularly look on the left-hand side to production, really can matter relative to what your conclusions are.

Next slide, please. So, we are going to look at a place where we are seeing a lot of LNG activity, in the Permian, because that is the biggest oil and gas producing region in the U.S. and one if of the largest, if not the largest, producing region in the world, currently. There also are tremendous amounts of methane emissions associated with that production. In this case here, it is concentration, not flux.

Next slide, please. You can convert that into flux. And, so, this was one of the earliest satellite-based studies using a European Space Agency satellite. Sorry, it doesn't have the citation here; it's the same as the previous one. What it does is show high variability in those emissions, but, more importantly, that the total emissions are much higher than the inventories. I don't have time now to get into it, but there are a lot of temporal dynamics and spatial variability; but these emissions are highly variable across the landscape. And the real question is, what's the boundary? Do you talk about producing gas at a single well and taking it out?

Next slide, please. Or do you think about the total system? One of the things with the accounting that really makes a difference is it turns out that over 80% of the wells in the United States producing gas are marginal wells that produce less than 6% of the total product but account for 50% of the methane emissions. Traditionally, these wells are not included in value chain and accounting, but yet, they're a product. So, the high-producing wells which tend to get looked at become these marginal wells over time. They're an integral part of the overall system. But, if you select only the high-producing wells, you have a large denominator of production and relatively low emissions, which is good. But they become these higher emitting sites, relatively speaking, later in their life. The analysis completely changes, so we have to think again, boundary conditions. Are we looking at the total life of a well, or are we only looking at a segment of the life of the well? Are we taking all the wells in a region or only a few? How you actually answer those questions makes an enormous difference in understanding the greenhouse gas implications of using LNG and processing it.

Next slide, please. And, again, the reason I'm saying this is we don't want to think about CO_2e; that's the standard that's used. The problem is you're implicitly making an enormous assumption about the timeframe and using 100 years, which for methane, in particular with LNG, is an integral part of the emissions. They're not all the emissions, but they're a central part because LNG is largely methane. It makes a big difference on that timeframe, and most of U.S. policy is not focused on 100 years. It's trying to accomplish something in a shorter period of time. So, you may end up using CO_2 100-year GWP, you shouldn't assume that it's the right metric to start with. You have to select metrics that work, and there are alternatives that are widely accepted and are completely consistent which will be aligned with the policy.

Next slide, please. And here is just some recent data. These are all great studies, but there are very few of them and we have very, very limited data. So, here's just comparison between a study last year that I described. From that, looking at a shinier supply chain that was published with several other studies, modeling or whatever. But the bottom line is, while these imply a lot of precision, we really don't have it because we do not have enough empirical data. So, most of this is modeling. Much of this is assumed and we really need to up our game and collect a lot

more empirical data if we're going to understand the implications of the LNG supply chain and make the appropriate decisions based on well-informed understandings.

Next slide, please. And here's a study looking at LNG shipping. This is the single study that I know of that really tried to look at what the emissions associated with LNG ships and moving shipping. And that's a great first step, but it's one ship and there's a wide variety of variation in LNG ships and how they operate. The issues of boil off, fuel usage, etc., all matter. So, this is a great first step, but it is not sufficient in order to understand the nature of the problem. So, we have an enormous gap, in particular in the shipping end of it, but not exclusively there.

Next slide please. Just showing you the contribution of methane slip, total amounts of methane, and these are the kinds of dynamics that really matter, which we need to get better data on to really understand. And, then in turn, I think what we'll see is there'll be opportunities to reduce those impacts once we have a more complete understanding of what's going on, which is certainly what we've seen across the natural gas value chain on a global basis. As we've learned more, we've found many more opportunities to reduce those impacts and, in most cases, dramatically reduce them.

Next slide please. Bottom line, we need much more empirical data if we're really going to understand these systems. We need to be very careful about selecting metrics and not just automatically assume CO_2 is the correct metric because in fact it creates spurious understandings in a lot of cases. Boundary conditions need to be communicated and selected carefully. This is a critical issue because in a lot of the analysis we're going to have conflicting results. Because you pick your boundary conditions differently, you do your analysis and you come up with things that are inconsistent among each other, and it's not because the undermanned of science is different, but because you solved the different or addressed the different problem. Thanks very much.

White, Sentho (PHMSA)

All right. Thank you, Steven.

White, Sentho (PHMSA)

And with that, I'll turn it over to Bob again.

10:10 AM State Regulators: Perspective on Key Technical Challenges

- Alex Kirschling, Natural Gas Engineering Supervisor, Public Service Commission of Wisconsin

Smith, Robert (PHMSA)

All right. Well, thanks, Sentho, and panelists Bill and Steven, and, really, the audience. So, let's move to our next presentation I'd like to introduce Alex Kirschling, who's the Natural Gas Engineering Supervisor for the Public Service Commission of Wisconsin (PSCW). Alex will be

providing some perspectives from a state regulator. Alex, please proceed with your presentation. Let me bring it up here.

Kirschling, Alex - PSC

Alright. Well, thank you very much Robert and thanks again for having me here today to speak on this. As Robert mentioned, Alex Kirschling, I'm the natural gas engineering supervisor at the Public Service Commission of Wisconsin. So, our agency in Wisconsin is responsible for oversight of the utilities in the state. So, natural gas, electric, water, and then we deal with some over the telecommunications companies, as well. So, any permitting for projects, utilities, generally, would have to get approval through our agency and then my group also inspects the natural gas facilities in the state for compliance with the safety regulations, and that includes the LNG facilities that we have, as well.

So, can you kind of jump in here, Robert, and go to next slide. As a state pipeline safety representative, we are a part of an association called National Association of Pipeline Safety Representatives (NAPSR). NAPSR is made-up of pipeline safety representatives from the various states within the United States, and, so, all the 48 lower states, the District of Columbia and also Puerto Rico make up NAPSR. NAPSR works closely with PHMSA. The states have a grant agreement with PHMSA, where PHMSA essentially delegates inspection and enforcement authority over natural gas pipeline and LNG facilities to the states, so any intrastate facilities in the lower 48 states are inspected and enforcement authority with those various state entities. I think Sentho mention this briefly, but, based on PHMSA's annual report data from 2021, there are 168 LNG facilities, jurisdictional to PHMSA in the United States. And, so, kind of put into perspective, the states' involvement with 100 of those facilities are permanent intrastate LNG facilities. That's the facilities that the states would inspect and have enforcement authority; and, in addition to that, there's the 40 mobile and temporary LNG facilities, which are also intrastate facilities. So, 140 out of the 168 facilities in the U.S. are inspected by the states and the permitting process, which I'll talk a little more about, would be with the various states, as well. So, of that, there's 30 states that inspect LNG facilities for compliance with Code of Federal Regulation (CFR) Part 193. That also includes four states that are interstate agents and inspect interstate pipeline or LNG facilities, as well for PHMSA.

Next slide please. So, they had this this up already, so I won't spend too much time here, but just kind of wanted to show the span of the facilities around the U.S. and that there's really a lot of states that have LNG facilities, especially in the Northeast. So, it really ranges from states where there's a single LNG facility all the way up to Massachusetts, which I believe – forgive me if I'm incorrect – but, I think they have 18 LNG facilities in the state there. So, really a wide variety and it's across the whole country in the U.S., too.

Next slide please. And, then a little closer to home for me, just kind of wanted to touch on the facilities that we have in Wisconsin. So, we currently have three facilities for LNG in Wisconsin, two of them are peak shaving facilities, meaning that they have liquefaction capabilities, as well. And, then there's one satellite facility where they have to get the natural gas truck to it since they don't have the liquefaction capabilities. And, in addition to that, we also have two LNG facilities under construction right now and those are both peak shaving facilities; they're one BCF natural gas peak shaving facilities, basically for the coldest days that we have and, certainly in Wisconsin, we can get some pretty cold days and in the winter. I'm looking outside right now,

and we're getting our first snowfall of the year, so the season is rapidly approaching. A large majority of the residents in the state rely on natural gas to provide heat in the winter. So, the LNG is the critical component, at least in Wisconsin, to ensuring that the customers are able to keep the heat on.

Next slide, please. So, I mentioned briefly about permitting and siting for intrastate LNG facilities. So, for non-Federal Energy Regulatory Commission projects, the permitting requirements really vary by state for LNG construction. I can't speak to individual states other than Wisconsin, but what I can say is that the Public Service Commission in Wisconsin at least has a dollar threshold, whereas, if the utilities are constructing a project that exceeds that threshold, then they have to come to our agency for permission to build that. So, for us, it's a little over $5 million and that amount is adjusted each year based on inflation metrics. The point I wanted to make with that is that basically any LNG project is going to exceed that threshold in Wisconsin. So, our utilities would have to submit an application and then be subject to approval by our commissioners. Then, throughout that process, it could be subject to interveners in the project. Myself and my group would review the project to make sure that it's reasonable and so on and so forth.

Next slide. So, when thinking about some technical challenges for LNG facilities, one of the things that I kept coming back to in my mind at least, was related to the general age of the facilities that the states oversee and, as I touched on earlier, how there was kind of a boom in LNG facilities back in the '60s and '70s when we thought we were running out of gas. So, a large majority of the peak shaving facilities out there are 50 or more years old. Out of those 100 permanent facilities, almost 2/3 of them were built in the 1960s or '70s. And that brings us to the three facilities in Wisconsin that are in operation currently, which were built in 1965, 1969, and 1974. So, they're all around 50 years old or more. When you've got older facilities, over time, naturally you're going to need some updates to them. Many of these facilities are grandfathered from the siting requirements that are put in place now. So, if the operators are to make changes, oftentimes, you're going to have to comply with those sitting regulations, too. And, there are some challenges there, especially in locations where maybe they built the facility back in the '60s or '70s. It was in the middle of nowhere and, since then, you've had encroachment from population expanding around it. So, certainly if there are ways to be able to make those changes while still complying with the siting requirements, then that's important to us. And another thought is that a lot of industrial plants go through basically where they'll shut down the plant for a brief period of time and then look over all of the components in the plant and make sure that everything is OK. And, oftentimes, that's not possible with LNG peak shaving facilities, especially when you have the tank and whatnot. In some cases, if you drain the tank, it takes a year or more to fill it back up, and when you need that to supply gas to your customers on the coldest day, you really can't afford to go without the plant for a year. It kind of comes down to the question of, how old is too old for things and are there other measures that can be put in place to ensure that the facilities are being upgraded, as well.

Next slide. Then, kind of on the opposite spectrum of that, where, at least in Wisconsin, we're seeing new facilities built right now, too. I know that the focus these days primarily is on the export facilities that are getting built for the U.S. But, at least in Wisconsin, where we're seeing that natural gas demand is still increasing here and in some other places, too, we don't have any underground storage. We don't have any traditional natural gas production. So, really one of the only ways that utilities can store natural gas is through peak shaving LNG facilities. Another

consideration is, in today's environment, it's a lot harder to get approval for a new pipeline to be built into the area, as well. So, we haven't seen one of those and many of the pipelines in our state at least are fully subscribed. It's a challenge for our operators to be able to get that supply and they have turned to LNG for that. And, on that note, even if demand for natural gas does decrease over time, we still need to have that gas supply for peak day. You know that there's always going to be the potential that we get our -30 °F day out and that's the last day that you want to have any issues with gas supply, too. I mentioned the two new facilities we have that are getting under construction right now are basically being built to supply gas to the greater Milwaukee areas on those peak days. So, again, we want to make sure that we're able to keep customers with the gas that is needed.

Next slide. So, throughout these projects that we have been getting built, we've learned a lot along the way about siting for the projects and I think this is one of the ones that I guess Bill touched on a little bit, too, but are there safe distances from the tank and other site equipment. So, when you're doing the siting analysis, there's certain modeling that you have to run and for various piping and the plant that couldn't release natural gas. But, if that piping is inside buildings, then you generally don't have to run the modeling for that. So, are there certain distances from buildings or whatnot that could be safe to protect the tank in the event that there's a catastrophic event. What other cascading events could occur? If you have an issue somewhere, could that lead to issues throughout the rest of the plant that may not be expected. In the siting, you have to look at the single accident leakage source for various pipes. So, is there a potential for releases larger than what's required in the analysis, as well? And, then the other thing is that the public perception from siting, too, one of the projects that we have getting built had a massive public outcry against the project. The measures can be put in place to be able to provide information to the public and make sure they're concerns are addressed.

And, then on the other note, are there ways to bring the grandfathered facilities into compliance with those modern siting requirements or is there a cost-effective means to be able to protect those facilities that are out there, as well, that were built before the modern-day siting requirements.

Next slide. And then design and construction. Obviously, technology has come a long way since the facilities that were built in the ‘60s and ‘70s. So, what other advances are out there in technology specific to construction to ensure that there are no defects in the plan, right? If you build the facility right, it makes it much easier to operate the facility and maintain it over time in a safe way. So, some things to consider would be preferences for nondestructive testing for welds on the tank and the various components and the facilities, as well. And is there other redundancy that may be good to design into the facilities? I mentioned that the last day that you want to have an issue with the LNG plant is the day that you need it when it's cold out. So, are those in place to be able to ensure that they operate safely, as well?

Next slide. And I mentioned the advances in technology, so LNG plants are obviously required to have an emergency shutdown system. But are there other areas where it could be prudent to isolate, to prevent having to shut down the entire plant and lead to damage in other places that may happen. So, is it prudent to be able to isolate smaller sections? Are there places where it makes sense to have automatic shutdown versus relying on a manual valve in places? Certainly, it may be easier in those cases to be able to shut down something from a safe distance away versus putting someone potentially in harm’s way to have to go shut off something. Are there

certain areas of the LNG facilities where it makes sense to have more automation to, again, add extra levels of safety in there?

Next slide. And another consideration is for inactive facilities. So, for whatever reason, if the plant is not needed for the time being or, again, if it goes out of service for some period of time, what, if any, requirements may be needed to ensure that those plants don't fall into disrepair during that time? Certainly, if it will need to be used again in the future, what may be some things that can be done to keep it ready for when it needs to be used again.

Next slide. I touched briefly on it earlier, but mobile and temporary LNG facilities. So, there are a handful of these out there and in certain places, where maybe seasonally you have to put a facility out or in certain emergency situations, you have excavation damage on a pipeline, and you need to keep providing gas. These facilities are a good option for that, but some of them may be used on more than just a temporary basis. How long is too long for using that temporarily? Are there other safety concerns with keeping those operating for a long time, certainly the siting of those, too? If they're in an area where the there's a lot of population nearby, what are the impacts of that? And, with these mobile and temporary LNG facilities, is there potential for use in response to helping lower emissions, as well, so that Congress had issued the reauthorization for pipeline safety. There was a Section 114 that basically required operators to minimize their releases of natural gas. So, as part of that, LNG facilities fall under that umbrella, as well. Are mobile facilities an option for operators to use to help mitigate those releases, as well.

Next slide. And, lastly, impacts on the public. The facilities, when they're sited, naturally they try and put them in a location where they mitigate the impacts on the neighbors, but there are some things that may kind of fall through the cracks in terms of impacting others in the area. And one of them being the lighting requirements. So, those are pretty specific in the code, right? You want to make sure that you have adequate security at the facilities and adequate lighting there, as well, but are there ways to mitigate or minimize the effect of that on the neighbors? Having those bright lights charting on the facility all the time? And you think of public awareness for folks in the area surrounding the facilities, too. The Part 192 requirements for pipelines that necessitate operators to contact the folks in their areas to make them aware about pipelines and whatnot. So, are there things that can be done to help ensure that the folks nearby these facilities are aware of their existence, as well. Then, training for local emergency responders, is there a period of time that's recommended for doing that? It probably varies by the location where the facilities are. If you're in a larger facility versus more rural areas where there may be a volunteer fire department or certainly one that not used to large facilities like this. So, some other considerations for that, as well.

10:35 AM Industry/Trade Organizations: National Perspectives on Key Technical Challenges

Panel Moderator: Mary McDaniel, Senior Technical Advisor, DOT/PHMSA

- Center for Liquefied Natural Gas: Charlie Riedl, Executive Director

Smith, Robert (PHMSA)

Alright. Alex, appreciate that. Thank you very much for the presentation.

Alright, panelists for the panel on industry perspectives, please be ready to unmute yourself when called upon. It's now time for our next panel. So let me introduce Mary McDaniel. She's the Senior Technical Advisor for PHMSA's Office of Pipeline Safety and she will moderate this panel on the following Q&A session. Mary, go ahead and proceed while I bring up the presentation.

McDaniel, Mary (PHMSA)
OK. Good morning, everybody. This panel objective is to learn about the technical challenges known for LNG facilities and to hear of any suggestions for measures that could be taken in research or otherwise to resolve them. This panel has four presenters included today, so our first presenter is Charlie Riedl. He's the Executive Director with the Center for Liquefied Natural Gas (CLNG). So, Charlie, welcome. And please proceed.

Charlie Riedl, Center for LNG

Thanks, Mary and Bob. Appreciate the invitation to be here. I'm going to continue on the comment that was offered earlier here today about not being a scientist or a technical expert, here. So, I want to just preface my comments accordingly. My colleagues who will follow me on this panel will dive further into this, but what I wanted to do ahead of that from an industry perspective, is offer just a framing of where we are now in the LNG industry from the large-scale export standpoint.

And, so Bob, if you can advance the slide, I'd appreciate it. Let me just talk a little bit about who the Center for LNG is and then we'll jump into my comments. We represent large-scale LNG liquefaction companies, as well as the major portfolio suppliers of LNG around the world who are utilizing LNG being produced here in the United States and distributed around the world.

So, next slide, if possible. I want to just talk a little bit about U.S. natural gas, how we got here, and why we are exporting natural gas. I think it's important to understand and some of the previous folks had mentioned on the comments this morning, right, we were a net importer, talking about becoming a net importer of natural gas at the beginning of the century. I know the comment was made earlier this morning, talking about the fact that we went from zero LNG exports in 2015 to now being the second largest exporter of LNG in the world in 2022. So, the first export of LNG in 2016 and now looking at having seven facilities operational in 2022, we have obviously ramped up our LNG export capacity quickly and so events like the one that finds us hosting today is an important opportunity for us to have this conversation. But none of that happens, obviously, without the fact that we have increased the recoverable amount of natural gas that we have here in the United States, significantly. And that has obviously been led by the shale gas revolution coupled with horizontal drilling and hydraulic fracturing. So, when we look at sort of where we're at as far as a recoverable number, it's up almost 80% in the last decade. So, every couple of years, the potential Gas Committee puts together an understanding of what we understand, as an industry, of how much natural gas is technically recoverable here in the United States. So, you can see that number is 3.8 (TCF) trillion cubic feet of gas.

So, an enormous number that we're talking about here, which then leads into the next slide. I'll talk a little bit about LNG, if we could just advance. So how do we get here, right? So, our name plate capacity at the current LNG export facilities is just about a little bit over 12 billion cubic feet of production on a daily basis. So, this chart, here, that I've got – hopefully everyone can see – is talking about the growth that we've seen in not only LNG exports, but also natural gas exports by pipeline, mostly into Mexico.

So, where we're at right now is just about 20 billion cubic feet of gas a day. That number will ramp up closer to 25 billion cubic feet by the end of 2023, depending upon when we get into a couple of facilities that are currently under construction for LNG exports here in the United States. But what that shows right is we were about 5 billion cubic feet, almost all of that was pipeline gas in 2016. And where we're at this point is now the LNG exports have actually surpassed the volume of pipeline gas that we're exporting on a daily basis.

So, if we can jump to the next slide. I want to talk a little bit about this because I think it's important as we frame up sort of the technical challenges here. It's important to understand that the markets are driving the activity that we're seeing in LNG, which will then obviously facilitate the conversation about how we can partner with the regulatory agencies that have oversight in our facilities more effectively and how can we make sure that we're continuing the safe operation of our facilities and focused on. That kind of an initiative in collaboration between the public and private sector. Since February 24th, when the invasion by Russia into Ukraine happened, you can sort of see what's happened with natural gas prices around the world. There was sort of a growing demand coming ahead of the sort of regular winter season that you can see here, here on the slide starting in October of 2021. And that number sort of increased, but the blue line representation, LNG prices, which decrease significantly ahead of COVID lockdowns that happened at the tail end of last year and in the first part of this year before picking back up again this summer for growth. What we are seeing, though, is that spike that happened as a result of the invasion back in February in European gas prices and the buildup since then, that right now European gas prices and LNG are actually outcompeting Asia for demand right now, which is why we have seen so much of the U.S. LNG production going to Europe. And, so, it's important that we're able to continue to provide our allies and trade partners with the LNG that they need, especially as we see countries like Russia weaponizing natural gas into Europe, the ability to offset or display some of the lost volume of natural gas that Russia had historically provided in the Europe with us. LNG is not only critical this winter, but for winters and seasons to come.

If we can go to the next slide. Just a quick sort of understanding since 2016 where we have been sending LNG, the majority of it has gone into Asian markets with the last year, though, the sort of, as I mentioned, in the previous slide, a significant volume of LNG going into Europe and that's really what I want to talk a little bit about. That means into this technical aspect, the growth that we have seen from demand in Europe and the market shift in Europe towards it, more LNG and more natural gas use from outside of Russia is going to underpin the next LNG projects that we'll discuss being built and becoming operational because long-term contracts are required for funding and construction of LNG facilities. The majority of those contracts which had been expected to be signed out of Asia, we will now see an increase growing demand coming out of Europe, as well. What that means is there will not be enough LNG on the water to satisfy demand and, in order to build additional LNG facilities here in the United States to help satisfy that demand globally, we will need additional pipeline. And, so, one of the major areas that we spend a lot of time talking about is the challenges associated with siting, permitting,

constructing, and then operating pipeline, natural gas pipelines in the U.S., but I think it's an important and critical conversation as part of the next two days that we not only look at sort of the LNG facilities, themselves, but also the pipeline component of this, which will be imperative in order to not only… We can't operate LNG facilities without the necessary infrastructure, including pipes to build that. And, so, there are, I think, enough projects that we're talking about, from an LNG standpoint, that are currently on the books or being proposed that the market will dictate how many of those get built. But the pipeline aspect of this is going to be critical, as well.

Let's go to the next slide. So, the interesting thing is I've had this conversation with a number of folks recently, here in D.C., when asked about how can the U.S. LNG industry do more not only for this winter, but also looking at next winner. And I think the interesting thing is if we were holding this conversation a year from today. So, let's fast forward to November of 2023. This slide that I'm showing right now will look the same, interestingly enough, right? The last project that is entered into operation and is not fully commissioned at this point, but the next project to enter operation is going to be the Golden Pass facility. And that facility is not expected to enter into operation until 2024. And, so, I think that sort of is an important aspect to highlight here, as well, as we're talking about updating regs and looking at what the potential for that might look like in additional research. The interesting thing being is that we won't have new facilities entering into operation for the balance of this year or leading into 2023. Best case scenario given supply screen and supply chain constraints would be 2024 before we will see the next large-scale LNG export facility enter into operation. So, I just think that that's an important aspect, especially as we just transition to the next slide.

And it continues to underscore the importance of where we are at right now, which is this growing demand in Europe. And, if we sort of look at where we are sending our LNG since September of last year through September of this year, which is the most recent data that we have published, it's a strong explanation as to where we are. Asia Pacific had largely been the market, and China had largely been the markets where we had been sending gas. You see that market share shrink in January and really sort of looking at the outsized volume of gas that has been going to Europe from the United States since January of this year, and we expect that continued growth in the European market to remain strong for the foreseeable future, even if the conflict in the invasion by Russia into Ukraine is resolved. At this point, we expect that there will be robust demand still continuing in Europe for the foreseeable future.

We'll go to the last slide. Actually, I've got two more and then I'll turn it over to my colleagues here. I think that this is an important component here as we talk about the importance of regulations and some of the areas that I know my colleagues will get into that will be important for large-scale facilities. When we look at the growing demand, right, in every single location around the world where the U.S. is providing LNG, the demand numbers are expected to grow. Those market shares are only going to increase the demand for U.S. gas. As a trade association that represents U.S. LNG exporters, I can tell you the conversations that we have increased in almost an eight-fold number this year, comparatively speaking, from foreign interests regarding how quickly LNG can enter and onto the water to help alleviate some of the supply constraints from natural gas around the world. So, all of these sorts of conversations are timely.

I just wanted to help better frame this up, and then we'll go to the last slide. Bob, if you could. Understanding sort of where we're at, I think a lot of this is important. There was just a quick question I can answer that on the previous slide as the dark gray area is to be determined (TBD),

which basically means that LNG is on the water and hasn't been delivered, on the one more slide back. Yeah, for September of 2022, that dark gray slide there, or that dark gray bar there represents LNG that has not landed, so it is left U.S. shores has not landed, and I think that's one of the interesting perspectives, that U.S. LNG has, is we have a flexibility in our destination. So, when cargos leave the United States, traders who own those cargos are able to send those cargos where they're needed – the market dictates where they need to go. So, that's why we don't have a report there. What I will tell you is similar to the previous months; if we were to go back and look at those months historically; the majority of that gray bar and the previous months will ultimately turn orange and head to Europe. And we know that those cargos, while they don't have an immediate destination when they leave the U.S., the vast majority of those cargos over the last 10 months have all wound up in Europe. Almost the 75 to 80% of all U.S. LNG cargoes have been going into Europe since the start of this year.

So, the last slide that I've got and then I'll turn it back, Mary to you is looking at the steps for approval and I think that this is important as we talk about the regulations that exist, obviously with PHMSA promulgating 193 and the efforts by industry to continue to look at modernization opportunities for 193. The other important aspect of this is, as these facilities that look to navigate through the regulatory approval process, that is not a short-term endeavor – that is a three-to-four-year endeavor. We're talking about a five-year timeline to build our facility. So, a project that is currently in a proposal phase would likely be operational sometime around the end of this decade. So, with demand on the rise and pressure from around the world for additional need for natural gas as countries transition away from coal and other dirtier fuels, demand for U.S. natural gas and regulatory certainty is going to remain critical. So, with that, I will conclude. I've got a slide there. You can check more out about us either on Twitter or at our website. But I look forward to the discussion here this morning. So, Mary, back to you. Thank you.

10:35 AM Industry/Trade Organizations: National Perspectives on Key Technical Challenges (Continued)
Panel Moderator: Mary McDaniel, Senior Technical Advisor, DOT/PHMSA

- American Gas Association: Kevin Ritz, Sr. Engineering Technical Specialist, Baltimore Gas & Electric

McDaniel, Mary (PHMSA)

Thank you very much, Charlie for your presentation. I think we'll do questions at the at the end for all the panels same time. So, next representing the American Gas Association (AGA), our second presenter is Kevin Ritz. He's Senior Engineering Technical Specialist with Baltimore Gas and Electric. So, Kevin, you please proceed with your presentation.

Ritz, Kevin L:(BG&E)

Thanks, Mary. Good morning, everyone. Again, this is Kevin Ritz with Baltimore Gas and Electric and Exelon Company (BG&E). I'll be presenting the AGA's position on the national perspective on our challenges in the LNG industry, and I'll frame that up with the focus of mine

is primarily on our peak shaving and satellite facilities, that being where most of my experience in my 45 years has been developed around.

If you could, next slide, please. I'll also be giving a brief overview of BG&E, some background on LNG and the development of the product and the industry activities, much of that's already been discussed, previously identified Horn D projects on the draw, some attention to those, and then the actual challenges themselves. I'll be putting out some general challenges and one or two more specifics that maybe will help engage in the afternoon and tomorrow sessions in the working groups. And then just a brief summary.

So next slide please. For BG&E, we were founded in 1816, so we are the nation's oldest gas utility. It actually started in 1816 when Rembrandt Peale first lit the first gas lamp in Baltimore, and some over now 200 years continues. Just some quick facts on our operations. We are combined gas and electric utility with the square. Mileage is stated as low over 3,000 for square miles for the electric. And it was a little over 800 for the gas system. We have approximately 700,000 gas company gas customers. We employ approximately 3,200 personnel. Our pipeline network consists of more than 7,600 miles; a portion of those 152 miles is transmission and we do own and operate one LNG peak shaving facility and one propane air peak shaving facility.

Next slide please. Much of this has been mentioned. I'll go through this really briefly. As mentioned, the surge began in ’65 and continued through the ‘70s to build primarily the peak shaving facilities and some base loads during the ‘70s, as well as the build out of a few of the original import terminals. Then there were also a number of peak shavers being supplemented by the build out of these base load import terminals. So, they were receiving their product from these import terminals that were now fighting. More recently, a number of those peak shaving facilities that didn't have liquefaction have started to install liquefaction for ease of operation. In 2003, we went through another phase or shift, where there was a report that we were going to have considerable deficiencies in our natural gas supplies. We were bringing in a product that was possibly high LNG product. It was possibly very high in ethane. They were talking about nitrogen injections and there was a lot of studies about interchangeability at that time, which needed to be addressed. Then, as mentioned, came along the shale gas boom. And, at that time, several of the existing import terminals began plans for constructing large liquefaction facilities as well as new LNG export facilities with storage and liquefaction were being planned and constructed. LNG, as mentioned, also has been leveraged for transmission distribution activities to offset gas outages and also as an alternate fuel transportation fuel and areas where there's stranded assets that need a source of fuel, which then also helps with environmental concerns and reducing greenhouse gas emissions.

Next slide, please. Again, summarized here, a number of folks have mentioned that we have 168 total facilities. This is all based on the 2021 PHMSA LNG report data. There's 72 peak shavers, 52 LNG liquefiers, 25 satellite, 28 base, 40 mobile, and 8 others. Of their 94 peak shaving and satellite facilities, 72 of them were, 77%, were built in the 1960s and ‘70s. And I believe one of our earlier speakers mentioned it – it's the age of the facilities and when they were constructed. I don't want to draw any unnecessary attention to those because, if maintained properly, we feel they can have a very long lifecycle. There are 44 of those facilities, 47 are in the Northeast, very heavy concentration, obviously. Of the 48 peak shavers in the northeast, 83% are of the 1965 to ‘75 vintage. Again, even in the northeast, we're seeing the older facilities. And, other 48 peak shaving and satellite facilities in Northeast 25% have liquefiers. Overall, the average peak

shaving plant was built around 1982, with the oldest peak shaving plants, three in the Simpson data indicating they were constructed and in service in 1965. And to demonstrate the ongoing efforts to construct these facilities, we have 4 new facilities in 2021 – one peak shaver, one satellite, two base loads; and that was one export and one storage with liquefaction facility.

Next slide, please. I just want to draw attention to the fact that, while this is may be the first LNG focused R&D forum, that there were prior since the Orange D forums that had an LNG element included. As a result of those previous R&D forums, these projects, and there are others – these are just some that I've listed for your reference – that have been conducted completed. These projects provided really valuable information on their topics. A lot of them did also present an opportunity or identify an opportunity where additional research may be helpful. So, I would ask, as you are in your work groups, various work groups, to maybe make reference to these, see if there's not opportunities out there for us to expand upon. Some of those, such as the cascading effects of Vapor Cloud Explosion process safety management facilities, hazard detection, layout, hazard mitigation measures, and vapor plant explosions at no wind conditions.

Next slide please. Here are some general challenges, which is the way I grouped this up. As mentioned, there's the general challenges that we face as an industry, not necessarily just as a peak shaver, but it's been mentioned about the pipeline constraints, the lack of new pipeline construction – very difficult to get sited. This is particularly evident in the Northeast, where we have quite a congested amount of peak shavers there. That presents challenges for those facilities and greatly increases the reliance on them. As mentioned, again, the streamlining of the regulatory processes we feel is necessary. As we're really experiencing unprecedented activity at both traditional and nontraditional type facilities, the peak shavers are performing upgrades and replacement projects to enhance the safety to facilities that the productivity of the marine terminals the build out of the large scale exports, all the siting design and construction activities and then transportation fuel facilities all could benefit from a more robust updated regulatory process, which might also include obviously adopting later editions of the consensus standards, such as NFPA 59. Currently we're under the 2001 edition for most all of the activities along with the 2006 for seismic. For the tank construction, that's a considerable amount of advancement that has gone – it has passed since it was republished and it's quite an opportunity managing these older facilities, and newer facilities present challenges in the design and engineering, which include variations in feedstock composition. When the facilities were designed, they were designed under criteria based on the gas coming into it at the time. That's certainly changed. Now we're talking about a new product that we're going to be presented with, which I'm going to go into a little bit more detail. And that's hydrogen enrichment that might show up at in the feedstock of our LNG facilities. Other general challenges are performing facility upgrades without jeopardizing grandfathering. Certainly, they're the facilities, in many cases, having been built prior to regulations that are challenged with siting and grandfathering risks, but yet that doesn't mean to say that there's not opportunities to enhance the safety of these facilities to perform upgrades meeting the intent of some of those. The pace of technology for control systems is unprecedented and also then managing the cyber security risks. And then there's the personnel training and retaining a skilled workforce. There's not a lot of folks that… You know, there's a lot of publicity right now about shifting our energy resources and moving away from fossils and it's possibly impacting the resource pool that we have for our industry.

Next slide please. Awesome, specific and emerging challenges. We're all trying internationally to reduce our carbon footprint. And that's a tremendous goal and one that is going to present many

technical challenges to achieve. There are several agencies performing various research projects on hydrogen. There's still a lot of work to be done out there to understand the impacts and what opportunities we have to retrofit or address this issue to maintain the reliability of our facilities. One such plan that's gained considerable traction is hydrogen enrichment. Again, aimed at reducing the carbon footprint. But it will be challenging particularly for existing LNG facilities to address. And, while there is you mentioned a number of efforts by various agencies and organizations and engineering firms, there's a lot of research that remains and I'll draw just a little bit of attention to a project. It's ongoing right now. And it's titled Impacts of Hydrogen and Rich Natural Gas on Feedstock for LNG Liquefaction. This is an ongoing project. It's just started up this year and will help us identify some of those challenges, but not all of them. And this is where we need PHMSA's assistance in this research effort.

Next slide please. Some of the potential impacts of the hydrogen enrichment that need to be better understood when it does arrive in their feedstock. And I say that is it's not. If it does, it's really when it does is the belief that we will definitely see hydrogen in our feedstock at some point. The impacts on liquefaction rates as a potential for longer liquefaction seasons impacting increased operational cost, increased power requirements. The power supply system upgrades will be necessary for those that are electrified plants with electric motors or increase compression because of the inefficiency or the changes in the composition of the gas and the effectiveness of compression on those. We also have to better understand and address potential effects on the facility materials, possibly lower operating temperatures, potential for stress corrosion, hydrogen stress corrosion, cracking, the permeability of existing gaskets and seals. And then there's the safety systems that we have to consider. Fire and gas detection – can they detect hydrogen in a release? Are there extinguishing agents that must then also be revised or added in the facilities? And then there's their electrical area classifications.

Next slide please. Some additional potential impacts for our LNG pump performance affecting the vaporization process. If there's in trained hydrogen in some level of solution in the LNG that could create problems in the pump for cavitation, there's some potential for product density changes and increases that may place additional loads on existing structures because of the density increase. We have to be able to manage the hydrogen product after it is at the facility either whether we pretreat it, remove it prior or post liquefaction. What do we do with it when it's on site? How do we transport it out of the facilities? Do we use a pipeline? Can it go in our plan to fluid, particularly those with peak shavers serving local distribution companies like ours? We have to maintain our tariff limits and such. All this has to be balanced to achieve the goal.

So next slide please. So, in wrapping up or getting close here, but opportunities to address the challenges, certainly promote the R&D projects as they become available as an outcome of prior R&D programs. I've been fortunate enough to participate in some of these. I found them very valuable rewarding and hopefully some of you have been able to attend some of the debriefings on those projects that PHMSA has hosted. Certainly, participating on the technical advisory committees on those R&D projects. Please participate in the consensus standards development process whether that be with API, Subject Matter Expert (SME), or NFPA. I actually represent AGA on the NFPA 59, a technical committee, and have done so since around 2005. Please participate in industry organizations, such as AGA and Interstate Natural Gas Association of America (INGAA), and participate in a regulatory process. Provide the comments to PHMSA, give them the industry perspective, your firms perspective on possible regulations, and continue

the preparation and support for petitions to promote changes in the regulations that are deemed appropriate. There are several that are pending that have been filed with them, more aimed at updating our regulations, so hopefully we will see those come to be in in the near future.

Next slide please.

In summary, our industry has an outstanding safety record and, while that is outstanding, there is always room for improvement. We must take the opportunities like this forum to enhance the design, operation, maintenance, and safety of the facilities. And, in closing, I hope that as a result of this presentation, it helps the rest of this forum in triggering some thoughts and contributions during the working group session. So, thank you very much for your time.

McDaniel, Mary (PHMSA)

Thank you, Kevin, for your presentation.

10:35 AM Industry/Trade Organizations: National Perspectives on Key Technical Challenges (Continued)
Panel Moderator: Mary McDaniel, Senior Technical Advisor, DOT/PHMSA

- America Petroleum Institute: David Murk, Director, Pipelines – Midstream
- Interstate Natural Gas Association of America: Chris Williams, VP Pipeline Operations, Cheniere, Inc.

McDaniel, Mary (PHMSA)

Our next presenter. They're going to present together, the next two presenters. So, they're going to do a joint presentation. So, let me introduce both of them to you at this time representing the American Petroleum Institute (API) is Dave Murk, Director of Pipelines Midstream with API and representing the Interstate Natural Gas Association of America. Our fourth and final presenter is Chris Williams. He's Vice President of operations for Cheniere, Inc. So, Dave and Chris, please proceed.

David W. Murk

Thanks, Mary, and good morning, everybody. I appreciate the opportunity to tag team on this with Chris and, as Charlie said, I am not, as well, the technical expert in this area. We work clearly with a lot of our member companies that bring that technical expertise, such as Chris, so as we are providing an industry perspective on large-scale liquefaction facilities, I want to give you the perspective from where I'm sitting, the more the higher-level regulatory perspective, and some of the changes that we're hoping to see, Kevin touched on that a little bit as far as streamlining regulations, but a fit-for-purpose set of regulations, and then the importance of consensus standards. Then I'll turn it over to Chris to talk. A little bit more into the technical challenges.

Next slide. So, what we're going to touch on, I'm just going to hit really quickly on who we are and, as API, and who we represent, as I mentioned, drivers behind regulatory change – Kevin, as I mentioned, hit on it – and we really do need to see a more fit-for-purpose, risk-based approach for large scale, why performance-based regulations make sense, what we're considering or what

we would propose as an industry to be that regulatory framework. And then I'm going turn it over to Chris to dive a little deeper into some of the technical challenges, and then the last thing is I'll touch on when I talk about API, the role of consensus standards – and Kevin hit on that, as well – and the importance of that mentioned NFPA 59A. And there's also some API standards that I'll close with.

So next slide. So, as a trade organization, I underlined a couple of key aspects. We represent all three segments of the oil and gas industry and that clearly includes LNG facilities and pipelines, as well. And the other important piece, and we've passed our 100-year mark last year, we've been in, we've been around or back in, I guess. As of 2019, we've been around for over 100 years, and we got our start really around standard setting and that's really a bread and butter of what we do for our industry. We have over 700 industry standards currently in place, or 800, for our industry across all three segments. So, again, we're talking technical challenges, research, and development, but all of that ultimately leads to and supports the development of leading industry practices through standards development, so what's going to be discussed today is absolutely critical as we continue to look at standards that might need to be revised, updated as 59A was. But are there other standards that need to be potentially considered for development around LNG facilities?

So, the next slide. So, who we represent? These are the companies, right now, that we have as various members that are currently in operation. We have members that have projects that have been proposed and then we have companies that have LNG operations in some form globally. And, so, this is just a quick snapshot of the companies that are API members.

The next slide. So, as I mentioned, you know as Charlie touched on, really the supply and demand and where the LNG industry is going and the needs for need for additional facilities and infrastructure as more and more operators come online, we've got to realize that the regulations that are in place that, that have been in place for years really, are not fit for purpose for large-scale liquefaction. Some aspects of it are, but the operations and maintenance piece, in particular, was really geared toward and tailored toward peak shavers that Kevin talked about earlier. And it's a little bit more prescriptive. The current regulations and 193 or more prescriptive versus being performance based. And, so, as we started to look at the regulations, we realized that they were really not fit for purpose and needed to be more risk based, and there are other proven approaches out there, such as Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM). Risk-based performance measures, as well, and really the importance of keeping up with technology and engineering practices within our industry is absolutely critical. So, in 2020, in the Protecting Our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act, we worked with Congress to get Section 110 added to the PIPES Act, which includes the requirement for firms to develop PSM, essentially like regulations for large scale liquefaction. So, important change that we hope PHMSA will get the reg out here over the next year or so. Important change for industry would be important for us moving forward.

So next slide. Why performance based? From an industry perspective, it's the scalable, flexible aspect of things. You have operators of all different sizes, operating in different ways. And, so, the risk-based approach provides for that scalable flexible type of an approach like we have through integrity management, current integrity management regulations for pipelines – it provides alternatives for various types of inspections, again less prescriptive, more risk based. And, as I mentioned earlier, there are other programs out there, like PSM, that have been proven

to be a good way to approach regulating the industry, again giving that flexibility and scalability to oversight. And then the ragged gap benefits, and we've seen that with within our industry and we think recognizing good engineering practices is key, so, again, moving forward, hope to have more performance-based type regulation for large scale liquefaction facilities.

Next slide. So, this is just a simple way to look at how we looked at... We had a joint trade group of INGAA Members, API members, as well as CLNG members, member companies in the three trades. We work together based on the PIPES Act Section 110 requirements and we looked at what makes sense from a framework standpoint for the industry, and we pulled in current 193, as I mentioned proven safety standards, best practices, and the statutory requirement.

Next slide. It came up with what we're proposing and this, I believe, is on PHMSA's docket for the rulemaking, but this is a proposed new section that is specific to large-scale liquefaction facilities. Kevin mentioned 193 needing to be streamlined and updated, agree there. But, also, we think there needs to be a more fit-for-purpose type of an approach for large-scale liquefaction. So, recommending a new part within 49 CFR.

Next slide.

So, at this point I want to turn it over to Chris to talk through before we close out with some of the consensus standard discussion. But I will have Chris talk about some of the technical challenges from an industry perspective.

Chris Williams

Thanks, Dave, and great to present with you and thank you PHMSA for putting this together and happy to be here to present an industry perspective on the technical challenges and the drivers. Probably just add a little bit of color to run some of the stuff that Dave has already talked about, and you saw from Charlie's slides, there was a huge market drive to increase the supply of LNG available to the world to capitalize on the advantages of LNG as a fuel that is clean, secure, and affordable. And that led to a wave of large-scale liquefaction facilities in the U.S., and these are a departure from the traditional peaking facilities. Sentho had a slide earlier around where she showed the footprints of various LNG facilities. The large-scale liquefaction facilities are large industrial facilities that are very large in scale that are represent a lot of investment and are required to operate it at very high reliability, very safely in the with the tightly scheduled maintenance. Then earlier we were talking about turnaround maintenance on that. We'll talk about that a little more in just a minute. Concurrent with that, we saw the development of the safety management systems and I know a lot of our friends are looking towards safety management as the safety management systems is the way to make the next step change in in safety across all pipeline facilities. We, in the industry, agree with that and are pursuing those, as well, from our side, and then continue development of technology and what we'll call reliability influence maintenance management. And as the maintenance management and the technologies that those systems depend on advance, it presents challenges to us from an inspection, maintenance, and regulatory standpoint.

So, if you can advance the next slide, please. So, as Dave and several people noted, the existing regulations do need to be updated based on some of these drivers. And, as the technology increases and as the requirements increase change for different facilities, we need to look at how

we do that. And alignment is going to be a key part of this process, and the alignment of all the stakeholder groups in this process. One thing that we that we note from the industry side is that there is quite a bit of overlapping by both PHMSA and Federal Energy Regulatory Commission with regard to liquefaction facilities and this, while not necessarily a technical challenge, presents a challenge to resources for the industry, as some of the requirements from both parties are similar, but not the same. So, we have to try and figure out how do we satisfy the requirements from both PHMSA and Federal Energy Regulatory Commission that are slightly different and do that with a limited resource base.

Next thing to look at is a stakeholder alignment on application of all the, we'll call, the panoply of things that we use to operate facilities, and those go from regulations, through consensus standards, to Original Equipment Manufacturer (OEM) practices and procedures, to industry best practices, to regard, which Dave mentioned, recognized and generally accepted good engineering practice, kind of the things that are common sense that we all ought to be doing. So how do we get the best mix of that and say how do we make this thing correctly so that we have the right amounts of all those and they're applied correctly and so that we can increase, and we can make that next step change in safety? Fortunately for us there are some people who have gone ahead of us. And there are parallel industries to us that have implemented these systems with great success. And, as Dave pointed out, we have the chemical industry with the OSHA process, safety management and the aviation industry, among other industries that currently have safety management systems deployed and we look forward to leveraging those industry partners and regulatory partners to help us as we travel on this journey toward safety management and, if you think about it, if you're going into an area that you're not as familiar with having the local guide is going to be tremendously beneficial to you. And that's kind of the approach, looking at if we have good local guides and we can make good careful progress it's going to allow all the stakeholders in this process to focus on what actually is going to move the needle for LNG safety as we move forward.

If you go to the next slide, please. As previously mentioned, the large-scale LNG production requires very high percentages of up time, and the maintenance outages tend to be tightly scheduled and tend to be of a turnaround nature and may or may not occur seasonally. And, so, that presents challenges to calendar-based maintenance programs, and we'll talk about that just a bit more in a second.

Second item we're thinking about is reliability maintenance systems can optimize maintenance strategies and increase safety through targeting, inspection, and maintenance correctly and that moves all the way from a calendar-based present preventative program through predictive algorithms on when to look at equipment and moves into even into real time condition-based monitoring. And the technologies that that are included with this are manifold and have been increasing as rapidly as technology has been increasing. I like that the Sentho put up an 8-track tape earlier in one of her slides. If you think about the advancements that have been made and in audio technology from you know the 1970s up through now, some of those same revolutions have been going on with technologies around maintenance and monitoring of facilities. So, they run the gamut, from vibration detection and through thermography, and through drone use. We're starting to see more virtual work done now, and some AI algorithms are being looked into. And I know PHMSA has some really good research programs going on with some of this. So, we have to leverage those technologies and find the best way to do that and, while doing that internally, we have the right regulatory framework in place that allows us to capitalize on those and increase

safety. Thinking back to the kind of the calendar-based inspection requirements that have typically been there with regulations, if they are not aligned with the scheduled outages, they become very difficult for the large-scale liquefaction facilities to be able to perform and perform safely. And something else to consider is, if you think about the typical reliability curve, people often call it the bathtub curve because as soon as you touch a system or a device or anything that you're going to maintain, you actually increase the chance that it will fail early on; typically, in the reliability industry, that's called infant mortality. So, for a short period of time after you have inspected something, there is a higher probability that it will fail. Then once it is gone past that initial period. And here's what's what we think of as the interface period for that device and then towards the end of his lifespan, it will tend to increase the probability of failure will increase. So, thinking about that and how we apply that to systems and how that relates to regulation offers a lot of challenges and a lot of opportunity for us as we look at regulation and how to incorporate those things into a right regulatory schema. And, as we talked about all the way from regulatory gap through OEM procedures through consensus standards and into regulation, how does all that fit in? And a lot of that can be applied across just about any area of large-scale liquefaction plant from the control system through safety systems, such as relief valves, fire suppression, gas and fire detection, and through prime movers, such as gas turbines and motors and piping systems. So, an exciting time, and it'll be interesting to pursue higher safety goals as we try and incorporate these things.

Next slide please. Along with that, we've talked about technology. Now let's talk about the technical challenges of people and processes as we look at the difference between existing and peak shaving facilities and liquefaction facilities. So, the staffing levels that you have at a large-scale liquefaction facility are much harder than you have at the at the traditional peak saving facilities or even the import facilities. Basically, the facilities and there is usually an increased use of contractors to perform maintenance, especially when you get into a turnaround scenario. And this really necessitates a lot of time and to have really good processes for coordination across personnel to ensure that we have work done safely while we're doing these things. So, some of those processes are going to involve the participation by everyone in the process on the client side of the process, hazard analysis and some of these, if you're not familiar with them, are process safety management terms. Are we going and look at the hazards that are associated with the process that we're currently controlling – control work processes and management of change. All those need to be fit for purpose and well deployed. Finally, looking toward the operating and maintenance plans and the causation personnel have to be fit for particular facilities as the facilities use slightly different processes to achieve the process goals. And that may present a challenge for our regulatory stakeholders as they travel to different plants, and they certainly present a challenge to how to correctly draft regulation to ensure that we have a good regulatory floor for safety and all those plants.

If you could advance to the next slide, please. And, with that, I'll turn it back over to you, Dave. He's going to spend just a little bit of time talking about consensus standards, kind of the middle of the pack of that spectrum of documents that we use to manage work and operate safely.

David W. Murk

Thanks, Chris. I appreciate it. So, yeah, just circle back and the role of consensus standards for us as an industry. Having a lot of different resources and tools available is key, right? Regulations we see are important. It's base, but there a lot of times we're developing standards

that either go above and beyond or are responsive to emerging industry challenges. And I would say with the API standards process, the nice thing is by American National Standards Institute, we're required to update our standards every five years regardless if it needs to be changed. So, on a five-year basis, at some level, those standards are being reviewed. So, it's important because it's keeping up with emerging challenges, changes to technology, as Chris hit on earlier and the importance of that, and how would changes to technology or engineering practices, leading practices; how would that impact changes to some of our standards, as well. And Kevin hit on the need to get 59 incorporated; I would support that, as well. And a lot of our standards are developed in a way to really support that risk-based, less prescriptive regulation; it's important to have a combination of prescription and risk-based approaches. But our standards tend to be more risk based, which allows for that scalability and flexibility. And, as you know, 193 incorporates by reference several standards, most partly 59A. And I wanted to hit on just a few other standards.

Can you go to the next slide? We do have a few standards in the LNG space and, again, as you're doing the work, additional research and development is being done. I can tell you, in all aspects of the oil and gas industry, as new R&D is being done, there are opportunities for updates to specific standards based on that research and development that's being done or in some cases we find that we need to actually develop new standards to meet again those emerging challenges that our industry is facing. So, we have API standard 620, which is on the design and construction of large welded low pressure storage tanks.

Can you go to next slide? 625 tank systems for refrigerated liquefied gas storage. Next slide. And this one is pressure relieving and depressurizing systems. And, again, if you look at the third bullet, it's the standard itself designed to aid in the selection of the system that's most appropriate for the risk, right. So, I think again it just touches on and highlights the importance of that risk-based approach and operators having some flexibility as to how they approach aspects of their operations and maintenance and integrity management.

And then the last slide before I turn it back to Chris his closings. Clearly, safety management systems and, Chris hit on in his technical challenges, the last one I think was people and processes. The importance of culture, importance of having qualified people and really safety management systems is threaded throughout any operations, any industry, through our member companies. So, the importance of safety management systems and strong safety culture, as well as important moving forward.

So, last slide. I'll turn it back to you, Chris.

Chris Williams

Yeah, thanks, Dave. And, to wrap all this together, we think that the LNG Center of Excellence is an absolutely wonderful idea, fully supported from the industry side. Thinking about the benefits of the LNG Center, we want to leverage the center to assist with these challenges as we move forward with the large-scale liquefaction regulatory updates. I think it is going to be a wonderful nexus for all the stakeholders, including regulators, industry, the standard organizations, academia, and even the public stakeholders. We welcome their involvement, too. The center is going to help us with that magical mix of how you apply standards and best practices and in concert with the regulations. That's a good meeting point for all the stakeholders

to get together and figure out how do we best deploy those to maximize safety. We can leverage the existing expertise across the related industries, our local guides, who have been there before, who can assist us and hopefully expedite the process of adopting this new regulatory scheme. And then, finally, it's a great chance to leverage training and education opportunities across the stakeholder groups and potentially solve some of the sticky issues that all of us have with trying to find the right talent and people who are going to be pulled into the industry to keep the industry moving forward for the next 20 or 30 years as we move forward with this.

So, with that, thank you. Once again, it was a great to be able to present to everyone and we'll turn it back over to Mary.

McDaniel, Mary (PHMSA)

Thank you both very much for your presentation today.