Brown, Tristan (PHMSA)
Good morning

I am very excited about this week's forum and we are grateful for your participation and input. I will be brief because we want to get to the packed agenda!

As many of you know, PHMSA's mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives. Nearly two-thirds of the energy consumed in the U.S. moves through PHMSA-regulated pipelines, the largest most-sophisticated pipeline system in the world.

This forum will serve as an opportunity for pipeline stakeholders to discuss research gaps and challenges in pipeline safety and emerging fuels, including hydrogen transportation—that have the potential to reduce safety risks, mitigate climate change impacts, and provide economic benefits to our nation and to 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 R&D agenda for the next 2 years, most of you are aware that pipelines are designed to transport specific products with specific physical and chemical properties and the market is the largest driver of demand for specific types of pipelines for many years. However, the true costs of transporting and consuming products through these pipelines that we transport, don't include the particular external economic externalities like pollution and climate change impacts, which just haven't been factored into the market supply and demand so this week 's forum will help inform stakeholders in PHMSA of the challenges and opportunities as the market transitions to newer fuels and begins to take into account those externalities.

The forum also helps facilitate discussions and illicit public feedback on several topics related to pipeline repair rehabilitation or replacement of leak prone and Legacy Pipeline and storage systems in order to reduce safety risks mitigated minimal impacts and prepare for future transport of fuels and those products that consume them. Overall, the R&D program is focused on implementing the administration's policies and priorities, which include making sure that transportation is an engine for equity for example, we know that many leak prone legacy pipelines exist in areas with high social vulnerability index. We hope this forum will inform how we can more quickly transition to safer transport in these areas.

PHMSA welcomes the input of all stakeholders and we're pleased to have over 600 registrants with representatives from public interest groups industry academia, intergovernmental partners and the public at large. We're also glad to hear from our friends at the Canada Energy regulator and the United Kingdom Health and safety executive finally as I'm sure you've heard on November 15th President Biden signed the over one trillion-dollar infrastructure and investment JOBS Act into law. This bipartisan infrastructure law authorizes a new grant program for the monetization of municipal and community owned high risk natural gas distribution pipelines. In addition, this law will facilitate development of a national strategy road map and R&D programs focused on the wide scale production processing delivery storage and use of clean hydrogen.

We have important work ahead of us to advance pipeline and environmental safety through an

improved leak detection and repair practices and technologies aimed at reducing methane emissions from our nation 's pipeline infrastructure. We're fully invested in helping the administration and our nation meet the climate challenge as evidenced by the funding provided by the bipartisan infrastructure law. You'll be hearing much more about our efforts in the coming months, but I just want to start by thanking you for joining us in particular, and to extend PHMSA's appreciation to the presenters that will be speaking over the next few days. We look forward to continuing to work with you on our collective goals of enhancing safety and protecting our environment.

With that I'll kick it back to Robert [Smith].

Smith, Robert (PHMSA)
Sure, thank you for that Tristan.

I'm going hand it back over to Alan anymore points would you like to make? The floor is yours.

Mayberry, Alan (PHMSA)
OK thanks Bob and also thanks Tristin for your remarks here also appreciate your plug for call before you dig 811 with your lapel pin scuba reminder to call 811 before you dig appreciate that, but anyway… Today's events will include a public meeting and it's in general session focusing on 2 objectives: 1) the current state of PHMSA's Pipeline Safety R&D and 2) safety environmental and infrastructure impacts have a shift to clean emerging fuels.

Tomorrow's agenda will focus on, or consists of, smaller interactive groups to develop robust R&D topics for funding consideration by PHMSA.

And the final day will include a report out from the workgroups to the general session, it's probably one of my favorite parts, there is in terms of Pipeline Safety Research Program Sponsors R&D projects focused on providing near term solutions for the nations pipeline transportation system that will improve safety, reduce environmental impact, and enhance reliability. PHMSA's R&D program is also focused on implementing the administration 's priorities through R&D investments that promote safety and Environmental Protection addresses climate change, economic recovery, and rebuilding and use of Transportation as an engine for equity.

Public meetings like this are vitally important that influence PHMSA to seek input from all stakeholders as we work to continuously advance pipeline safety and Environmental Protection and to sponsor innovative research over the next 2 days. We look forward to hearing stakeholder perspectives from all aspects of our industry, including the international presenters that Tristan mentioned PHMSA is looking at ways to position the pipeline transportation sector for the infrastructure of the future. This includes upgrading systems to transport hydrogen and other Renewable Resources, which will support the administration 's initiatives on climate solutions and job creation.

As we previously discussed with industry, one way that PHSMA was looking to advance technological solutions was to create a robust pipeline research and testing facility that catalyzes

innovation from the private sector, universities, and other research organizations. You may recall mention of that at our last R&D forum and discussion. You know specifically it's the facility that we were discussing in Pueblo, Colorado, just to give you a brief update we're on hold on that project pending some reporting requirements and assessment of the feasibility of such a facility and while we're doing that, we have that project on hold. But they'll just give you an update on where we stand on that.

Now the next 3 days provide a venue for industry to openly share information and to further strengthen things in knowledge and understanding on challenges and to foster new synergies and research partnerships so that our collective efforts remove barriers and advanced pipeline safety and climate solutions.

Beth Stimatz (Guest)
Sounds good.

Mayberry, Alan (PHMSA)
We appreciate the time and effort that R&D staff put in preparing for and holding these very important meetings also want to extend my gratitude to the many participants and speakers that we'll hear from over the next few days and finally to all of our participants for taking the time to hear and discuss ways that we can address identified gaps and move technological advancements forward to strengthen pipeline safety protection of the environment and position ourselves for the infrastructure of the future.

With that thank you very much again for being here, Bob will turn it back to you.

Smith, Robert (PHMSA)
Well, thank you very much for that. Alan let me go ahead and bring up the first presentation. Alright, hopefully, you can see that.

Our next agenda item and first presenter is Sentho White, director of the engineering and research division within the office of pipeline safety should provide a brief overview about our research program and how PHMSA plans to address the administration 's priorities, which includes climate solutions to reducing greenhouse gas admissions. Sentho over to you.

White, Sentho (PHMSA)
Thanks Bob and good morning, everyone, or good afternoon to those that are joining us from across the pond. I'm Sentho White, director of PHMSA's engineering and research division and the office of Pipeline Safety, and I'd just like to take this time to override an overview on PHMSA's R&D program, our current research initiatives, and upcoming focus areas that include hydrogen safety… next slide, please.

As background PHMSA's research programs are congressionally mandated to address specific reporting requirements on its research projects from 2 federal acts. The act of 2015 and the pipes act of 2020… next slide.

The DOT has defined and prioritized 5 strategic pillars to reflect the goals of the administration. The first being to make our transportation system safer. The second is growing the economy.

And next is equity to address inequities and meet the needs of underserved communities and then climate to mitigate adapt to and reverse the effects of climate change and transformation to prepare for the future transportation system.

PHMSA Pipeline Safety R&D activities support the DOT strategic goals by funding projects that directly contribute to the administration 's goals and safety climate and economic growth. PHMSA representatives also participate in several departmental initiatives such as DOT Center for climate change… next slide, please.

The mission of PHMSA pipeline safety research program is shown here on the slide and the goals of our program include providing research needed to manage public safety risks associated with the transportation of hazardous materials providing information to inform pipeline decision makers on regulatory and outreach initiatives leveraging resources to solve multi modal safety concerns and driving safety innovation and tech transfer… next slide, please.

This slide shows how PHMSA is able to achieve a comprehensive research strategy and the primary method is through our R&D forums where participants like you can provide significant input and discussions through interactive working groups. We also evaluate submitted gap ideas received through our web portal and interaction with collaborative partners such as our sister federal agencies public interest groups research organizations and the pipeline industry also provide great input. And important initiatives within PHMSA or from the Department or the administration could also drive what we solicit and fund. All of these inputs are developed into a research agenda that is reviewed by the pipeline safety R&D program staff and PHMSA leadership for approval and before soliciting and awarding on research projects… next slide, please.

As part of PHMSA statutory requirements when the research program was first established in 2002, Congress directed PHMSA to collaborate with pipeline stakeholders through various consultation processes that list is shown here. While not exhaustive, shows how important our forums are to bring in various representatives together to identify nationally and internationally recognized pipeline safety gaps and challenges. Next slide please.

As shown here PHMSA R&D Program Awards research through 4 subprograms utilizing public, private partnerships with academic institutions. Small businesses, research entities, and technology providers and federal agencies. The Outputs from these research projects advanced technology products and knowledge transfer for pipeline decision makers now starting from the top left of the slide and working down our CAPP program. Also called the competitive academic agreement program partners with universities to conduct innovative research on pipeline integrity challenges and also exposes students to subject matter. That's common to pipeline engineering to encourage career placement within the industry and later on this afternoon Kandi Baracatt will be providing a more in-depth overview on our CAPP program.

Now the research outcomes from CAPP are intended to be handed off to either a small business through the DOT small business innovative research program or through follow-up research that can be performed through our core program to develop more mature research and Tech Development. PHMSA’s core program funds research to tech providers and research entities to

develop ready to use pipeline safety solutions and PHMSA also collaborates with several federal agencies, including NIST, FRA&A few other, labs, including Sandia on pipeline safety research projects…Next slide.

PHMSA has invested almost $7,000,000.00 of funding into pipeline safety R&D projects since program 's inception in 2002 and since 2013, when CAPP was launched awards have been made to 25 universities and involved over 344 students in pipeline research, and that number is still growing…Next slide please.

PHMSA R&D program has shown very strong performance in advancing technology development and products into commercialization.

PHMSA funds 50% of the project costs, with a researcher on tech-based research and since 2002. There have been 76 projects resulting in technology demonstrations as well as 33 commercialized technologies and 16 patents have been granted that have stemmed from PHMSA R&D Investments…Next slide please.

The program also tracks the number of visits and research report downloads from its website and to date, since 2008, when we first started tracking these metrics, the online web portal has had over 41,000,000 visits and over 2,000,000 R&D files downloaded and additionally over 260 R&D final reports and 237 Conference and Journal papers have resulted from them to funded projects since 2002 and these metrics not only show the high interest in our program but also the importance in the research results to pipeline stakeholders…Next slide please.

And we hope to continue this high success rate, and performance as we focus on several important programmatic areas in fiscal year 2022.

In the next 2 slides identify the anticipated 2022 pipeline safety research program priority areas. The first priority area is on advancing alternative fuels research which is a focus of 3 of the 6 working groups on tomorrow's agenda and other high priority focus area is pipeline leak detection as PHMSA regulated pipelines account for roughly 33% of the total emissions from the oil and gas industry that this area continues to present challenges, but PHMSA plans to heavily focus its research efforts in this area. Research also on improving the safe operations of LNG and underground gas stored facilities will continue to be a focus in FY2022...Next slide.

PHMSA also plans to invest in research addressing pipeline anomaly detection and characterization repair and rebuild station and also pipeline threat prevention and research investments in developing new or improved technologies in all of these priority areas will not only aid in the prevention and reduction of pipeline leaks and ruptures, but will also enhance public safety and generate substantial climate benefits and methane emissions reductions…Next slide.

In responding to this administration's agenda on equity and climate PHMSA plans to implement several initiatives through its programs as I'll describe in the next few slides. The Biden Harris administration through executive order 13985 has committed to pursuing a comprehensive whole

government approach to advancing equity for all Americans. Thus, creating opportunities for the improvement of communities that have been historically underserved.
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And just as deputy administrative Tristan Brown and also Alan have mentioned aging cast iron pipeline systems, some dating back to the 1800s are in urban and more heavily populated areas, such as New York City, Boston, Detroit and Philadelphia and PHMSA R&D Program has previously funded research to evaluate the integrity of casts are inlined specifically in 2015 with a project to develop a model to characterize the fitness for service of cast iron lines and we plan to pursue further research focused on advancing technologies to rehabilitate and repair a cast iron mains.

And Working Group One on tomorrow's agenda will be exploring potential research topics in this area… next slide.

The administration through executive order 14008 is also committed to advancing climate solutions and through this EO created the justice 40 initiative and the goal of Justice 40 will be to deliver 40% of the benefits of federal investments in climate and sustainable transportation to historically disadvantaged communities, and DOT recently kicked off to justice 40 initiative this month with public meeting sessions and is in the process of developing the framework for the agency and as mentioned. Early occurrences staff are also participating in DOT setup for climate change and Doctor Sherry Borner with PHMSA office of policy and analytics is the current chair on the Environmental Stewardship Research Working Group for DOT PHMSA. It is also in the process of addressing the congressional mandates from Sections 113 and 114 D of the pipes act of 2020 and identifying R&D projects that are focused on methane mitigation…Next slide please.

PHMSA R&D program will also address the administration 's initiatives on clean energy alternatives and net zero emissions goals by 2050 by pursuing research in advancing the safe transportation of hydrogen and blended hydrogen into natural gas pipelines as well as the safe transportation of CO2 by pipelines…Next slide.

PHMSA regulates the transportation of gaseous hydrogen under 49. CFR Part 192 and of the 1,000,000 miles of pipelines from deregulates. There are less than 1600 miles of hydrogen gas transmission pipelines.

In order to ensure the existing natural gas pipeline infrastructure can transition over to transporting hydrogen safely and reliably, additional research is needed to answer gaps on the impacts and risks that appear with hydrogen and blended hydrogen on pipeline system integrity materials design as well as hydrogen storage and so that's why we're here. Working groups 2, 3, and 4 on the agenda tomorrow will identify research gaps addressing the integrity of underground storage.

For hydrogen impacts of hydrogen and blended hydrogen on pipeline infrastructure components and reliability of inline inspection tools with hydrogen gas and blended hydrogen and so please make sure that you participate in the upcoming panel discussions that are coming up. Next on

our agenda, as well as attend tomorrow's working groups, and the report outs from those working groups that will be on Thursday…Next slide.

And with that before turning it back over to Bob. I'd just like to say that the success of PHMSA R&D program could not be achieved without the hard work and dedication of these 3 team members that are listed here. Bob and Nathan and Kandi, as well as a secretary interns that we have, Narrate Rottenberg and Lindsey Sonic so big virtual clap really goes out to this phenomenal team and so just wanted to say thanks guys and now back over to you Bob.

Smith, Robert (PHMSA)
Well, thank you very much indeed.

White, Sentho (PHMSA)
Thank you very much.

Smith, Robert (PHMSA)
Let me go ahead and stop sharing this.

White, Sentho (PHMSA)
Let me go ahead and stop sharing this.

Smith, Robert (PHMSA)
And bring it the next presentation as I introduced the moderator. Alright with that our next agenda item and first panel discussion on the agenda so the panel is for one public interest discussion. Please be ready to unmute yourself when called upon.

So let me reintroduce Sentho White, who will moderate this first panel discussion and the Q&A Session. Following this panel as a reminder, please hold all questions until the very end. After all presenters have had an opportunity to speak…Sentho.

White, Sentho (PHMSA)
Alright Thanks Bob and good morning, or good afternoon again everyone and we appreciate everyone 's participation, especially our presenters to help generate input on our future research agenda. I have the pleasure of moderating the first panel and the objective is for our panelists to provide their perspectives and really generate a good discussion on how PHMSA's R&D Program can further advanced pipeline safety and reduce methane emissions while also developing innovative solutions to safely transport emerging fuels such as hydrogen by pipeline. I'm pleased to introduce our presenters, Steven Hamburg, chief scientists with the Environmental Defense Fund and Bill Carob, executive director of the pipeline safety trust. And Steven will be presenting first on EDF perspective and so with that over to you Steven.

Steven Hamburg
Thank you so very much and it's a real pleasure to be here today, and I really would just like to tee up, I'm really excited by the conversations that will be occurring and I'd really like to sort of tee up how we can really meet. This this very critical. The agenda that was just outlined, so, if I can get the next slide, please.

And it really is incumbent that we think about the full suite of the issues that were outlined in terms of needing to meet. Obviously, the safety and economic benefits of pipelines and storage, but also to ensure that, as was mentioned, that we address the climate crisis and the imperative of being able to ensure that we're dealing with these issues equitably.

And so what I'd like to do is use methane and natural gas pipelines as a vehicle for talking about the challenges we have and then extend that in particular, to hydrogen, but obviously it fits across a carbon dioxide as well next slide, please.

And as we think about the climate implications of different greenhouse gases, they have of course, inherently different characteristics. So, this is just the curve of what happens to gases that are put into the atmosphere. CO2 as well-known will get taken up by the oceans and by the terrestrial biosphere and persists of roughly 40% of it will persist on for millennia and with methane, which is a much shorter-lived greenhouse gas, it reacts in the atmosphere and by 50 years it's gone and with an average residence time of roughly a decade. So, what has historically happened is we've thought about that is CO2 is really the critical greenhouse gas, but in fact, it really depends on the temporal perspective that we have because in fact, methane accounts for more than 25% of the warming we're currently experiencing and over the emissions that happen over the next few years, will of methane will totally determine the change. Not totally, excuse me, it will dominate the impact on the climate that I will see in my lifetime the changes that I will see because methane is such a potent greenhouse gas, so we have to be careful in how we think about the 2 climate problems, we have. What will happen in the near and medium term, which is heavily influenced by methane and what will happen in the long term, which will be influenced of course, by CO2 so we really have 2 sets of problems we have to solve if we're going to address the climate crisis and we have to add to that Hydrogen, which is also a short lived indirect greenhouse gas, I'll come back to that in a moment… next slide, please.

So, it's been amazing, the amount of technological improvements that we've seen which is really giving us an opportunity to manage pipelines in ways and storage in ways that we never could before and in thinking about methane we really had the advantage of some really important developments in technology roughly 15 years ago that allowed us to have fast response High Precision Instruments so we could start to understand methane emissions and patterns of methane in the atmosphere that we never could see before.

This is a picture of a Google Street View car that we've used in a collaboration with Google over many years to monitor methane emissions from local distribution systems simply putting the instrument in the rear of the car and then having an intake at the front of the vehicle allowed us to be able to build models and algorithms with that. We could quantify methane emissions from leaks by simply driving the Street car with the traffic… next slide, please.

And then we produced a series of Maps for 13 cities across the US showing the location and size of these different types of emissions or leak indications and they vary enormously in terms of as was discussed. We have a lot of leak prone pipe cast iron in Boston, which was replaced in Indianapolis and the pattern of leaks or emissions leak indications varies greatly. But that's not the end of the story. There's much more to this story and we need to have much more data if

we're really going to manage these resources effectively and in turn, then of course, manage the resources that we need moving into the future where we have a more decarbonized economy… next slide, please.

So, these are data we put together using those measurements that we took with the group Google Street View cars in the group at Colorado State that we worked with and the paper we published last year where for the first time we really could look at the leak indications per mile with the age of the pipe… and one of the challenges, I'll come back to, but one of the challenges is these data don't exist. You can't find the age of pipe except by going to and working directly with utilities. Yep, this is critical information that we really need across the US yet we don't have that we really need PHMSA to work with the utilities and the companies that are owned these assets to really make this data available because it would be transformative relative to understanding the patterns age does matter in pipes and it matters. Then I'll come back to this again in the types of material we use so we need these kinds of data. This is the first such curve that I'm aware of to be able to understand how we move forward in both environmentally prudent way as well as a economically appropriate… next slide, please.

And this is just…next slide. Please a highlight of some of the specific results comparing on the right-hand side. Next slide, please all the data that we collected in this study that we published last year versus the longtime standard the EPA GRR I study from 92 and the update of that by Brian Lamb and the group in 2015, which was a study that we helped coordinate but the key is that I'm just highlighting if we look at for example, bare steel pipe the number of samples in the original study in the 90s was 20:00 in the Lamictal study it was 74. It's 826 in this study, but those are still compared to the IT was described the biggest pipe network in the world. We have relatively little data… next slide please

Even if we take all the data we collected we have 4000 little over 4000 points to look at when in the 92 study we had there were 60, 4:00 in the Lamictal 142 we are really data limited. We're not going to understand these systems unless we really expand the data that we have and we can do that with this modern technology we have if we have the underlying data and make it more transparent, which it currently is not…next slide, please.

So, we need better data. We need to have better data characterizing pipeline spatial distribution by age and pipe type and then we can really start to understand how they are performing because as we know it's very different from place to place. I happen to have had 100 year old plus pipe in front of my house. I use natural gas in my boiler here in Providence and you know they struggled because of the material in which that pipe was laid to find leaks for years until they finally simply got rid of the pipe and replaced it and we need more high accuracy quantification surveys of all types of pipes and storage. We are dated limited on these quantification. There simply isn't enough data available and we need to balance the budgets with respect to methane and/or hydrogen. We can't do it currently in a come back and visit that and we need to be able to do leak rate assessments on new materials and new applications.

In the lab that is some critical first step, but not sufficient. We need to take it out into the field and understand how they perform because right now we are not doing that. We don't have that data, particularly as it respects to hydrogen… next slide, please.

And if we just look at the data that we generated looking at the natural gas local distribution pipes, this is a distribution curve for the estimate of how much methane is being admitted on an annual basis. It's a probability distribution and if you look at the left side you see the Blue Triangle, that represents currently EP 's current estimate in the paper that we just published last year, the Red Triangle at the bottom indicates the mean emissions that we estimated. So, it's dramatically higher based on a much more robust data set than existed before and the 2 the Green Arrow…the green bar below…it represents the fact that historically we've underestimated the number of leaks by probably a factor of 3. In other words, with 2/3 of the leaks were not being measured because we didn't have good technology and currently the standards for what technology is required don't include the majority of the leaks and we've shown that with multiple utilities and when you increase from what historically the distribution to be too is the Red Bar, the Red bar above that is, you get to this higher commissions rate so again, we're data limited. We need better data. We need to understand where the leaks are what the pattern of leaks are because then not only can we do the root cause analysis, but we really can also understand what the performance is if we're going to get to minimizing leakage beyond, we have to absolutely safety is critical. No one would dispute that, but we also have to minimize it for climate benefits… next slide, please.

And if we just look at the total number of leaks, these are just distributions again and the leaks per mile of main this is an updated data. There is uncertainty, and we need to reduce that uncertainty by increasing the amount of data that we have. We have the technology, we have the need there is the mandate, but we don't have the data. We've got to create a much more robust data system and then we can answer these questions far more effectively… next slide, please.

And as we think about this, this is just trying to show the uncertainty generated by pipe type and age, so rather than generalized curve here have each of the different pipe types. The uncertainty showing the age effect on the emissions leak indications and not the absolute emissions. But just the number of Points of emissions and there's too much uncertainty here and this type of data didn't even exist before 2020 when we published this paper. And yet it ages at least I heard and working in the field in the last decade, you know lots of people saying age doesn't have much influence well it clearly does have influence and it makes sense that it would have influence and we need to address these issues… next slide, please.

And when we look at the whole natural gas supply chain and this is from some work that we published in 2018 building a natural gas associated methane emissions estimate for the US across the supply chain the right-hand side. The local distribution. The transmission in storage are those elements. We have at this point, the least certainty about we don't have nearly as many measurements over the last decade. We've collected a lot more data. There's still more to be collected on drilling and production gathering and processing we but we can use remote, sensing techniques, now that really allow us to come up with really robust estimates and do that on a routine basis in ways that we are not yet equipped to be able to do on the right hand side and our challenges and these estimates are a little dated the numbers are still the older EPA numbers and we know that on the local distribution it's multiples of that there's still relatively small compared to the drilling and production. But the uncertainty is very large and that's not acceptable… next slide, please.

And then we need to think about this issue of doing budgets. This is just illustrative of the global methane budget, which is not fully balanced. It is in this diagram, but there's a lot of too much uncertainty in the global research communities working on it as well. We need to have budgets for the emissions of these gases within our environment and understand the uncertainties and minimize those uncertainty… next slide, please.

And this is some recent data that was just published about Massachusetts and Boston Metropolitan area by a group out of Harvard. It's Sergeant at all earlier this year, which I think really makes this point dramatically so the Department of Environmental Protection estimates around the bottom. there are 2 different versions of it, saying how much is beat loss of natural gas and the through the infrastructure and then the direct measurement over many years is a very robust data set and the top and the gap between them is huge so there's roughly 2 to 3% loss of the thermogenic gas that enters the Metropolitan area. And yet the inventories are showing that it's roughly a half to a 3rd of that being lost or even less and that's not acceptable. We don't actually right now know where the rest of the gas is. We know some of it's coming out of the sewers. We've measured that; we know that both in Indianapolis and in Boston, but we can't balance the budget. We don't know where that gas is coming from we've got to solve these problems. We've got to focus on understanding what's going into the system? What's leaving? What's being consumed and then we can be confident that we know how to use these pipelines effectively moving forward… next slide, please.

And then we come to hydrogen. Hydrogen leakage matters as well, particularly if we're going to think of it as a decarbonization tool, which it has a lot of potential because hydrogen is an indirect short lived greenhouse gas, it does cause a reduction in hydroxyl radical cousin reacts with it, which means you have more methane for longer. It also forms tropospheric ozone and Stratospheric water and the bottom line is we have almost no data on hydrogen leakage from the supply chain. These are just some numbers from the literature, but they're highly uncertain and part of the reason is we currently don't have the technology in place to be able to measure in situ at the low levels to be able to determine leak rates of the scale, we need to ensure that in fact, the leakage is not undermining the benefits of hydrogen so we've got to get on with that kind of work and we've got to do that proactively not in response, like with methane. The infrastructure existed and we then have to go back and figure out what's working and what's not.

What we should be doing that proactively ahead of time and ensuring that we understand how the materials are interacting on what conditions they're likely to leak, how the materials age because we know hydrogen is a complicated molecule. It has a lot of impact, and it is a small slippery molecule that's very buoyant. So, it's not going to behave like methane. It will even though there's some data to suggest that leaks at the same rate there's really on first principles more. It's much more likely it will leak more to a larger degree than methane will and we've got to get our hands around that, in order to use hydrogen effectively moving forward… next slide, please.

So, we really need to think about this. What is the future of existing pipelines? I don't think the assumption that we can just repurpose it is appropriate. I don't think we have the information to be able to actually assess that should we phase out the existing systems should they be replaced

should they be repaired? I think without more data. we can't begin to answer any one of these 4 is the appropriate answer …next slide, please.

And then I'll just end with some thoughts on research needs.

And we really need to develop low cost, fast response high precision instruments across the different materials, particularly for hydrogen. We have them from methane, but they need to be cheaper and they need to be more broadly deployed. We need to understand where we're going to need a pipeline and where we're not in a decarbonized economy, rather than just assuming that pipelines will automatically be extended, and I think that we really need to think about that hard and do the underlying work to determine the optimal use of pipelines and storage and then we need to determine how emissions data can be collected cheaply and routinely across the full spectrum of infrastructure materials being transported. Thank you very much for the listening and I look forward to the following conversation.

White, Sentho (PHMSA)
Great thank you, Steven, for that very interesting presentation. It definitely shows that you know data is key to us making informed decisions and with that, I'm going to move on to our next presenter and that's the bill carom who's the executive director for the pipeline safety trust and build and turn it over to you.

Bill Caram - Pipeline Safety Trust (Guest)
Thank you, Sentho.

Good morning, as Sentho said I'm Bill Carrom, the executive director of the pipeline safety trust, and I want to thank PHMSA for inviting me today to participate in this forum.

I want to start right off the bat by stating that I am not a scientist or an engineer. So, I have a lot to learn from everyone else here on the technical side of Pipeline Safety as I just did from Stevens great presentation. But what I would like to share with you today is the public perspective on things as research and development program. How these tax dollars can be put to their best and highest use to keep the public safe from the risks of pipelines. But before I get into that, I'd like to introduce who the pipeline safety Trust is and where we came from for those of you who are not familiar with us… next slide, please.

Pipeline Safety Trust was born out of a 1999 tragedy in Bellingham, Washington, when a hazardous liquids line ruptured and spilled a quarter 1,000,000 gallons of gasoline into a salmon stream that runs through the middle of our town. The spill, and subsequent explosions, stole the lives of 3 boys and killed every living thing in and along a 2 mile stretch of Creek and you can see here the heartbreaking note that Liam left on the refrigerator for his parents that day. Next slide please.

The families of the boys and the community at large successfully advocated for funding as part of the criminal penalties paid by the operator to create a public interest watchdog to improve pipeline safety which became the pipeline safety trust and you can see here, Judge Rothstein 's words that day. There's going to be a trust that's going to be funded as part of today's sentencing

with $4,000,000.00. They've nowhere near the lobbying potential of the oil industry. It's not even David and Goliath. It's more like Bambi and Godzilla. No industry police is itself very well. You need outside people, and these are going to be the people so pay attention to them and we thank you for doing that today. Next slide please.

The pipeline Safety Trust is the only national nonprofit organization that focuses on pipeline safety and we do this through education and advocacy, increasing access to information and building partnerships with residents. Safety advocates government and industry that result in safer communities and a healthier environment. Next slide.
We appreciate that the focus of this year's conference is on emerging fuels and other ways in which to safely tackle climate change. The pipeline safety trust recognizes that climate Destabilization is one of the greatest risks posed to public safety by pipelines and vows to be bold in ways to combat those risks while ensuring the integrity of the pipelines that run through our communities and treasured places remains our primary mission is dedication to protecting people in the environment from the risks of pipelines requires us to also work towards a rapid reduction of greenhouse gas emissions. Next slide please.

If you look at this Venn diagram, you can see, there are issues that are purely safety related purely climate related and issues that have both safety and climate implications. In reality, it is getting harder and harder to separate climate issues from safety issues as climate change threatens the integrity of pipeline infrastructure through extreme weather events, subsidence, landslides, flooding, scouring permafrost thawing and other climate related disturbances issues to be discussed at this forum that are ostensibly climate issues such as hydrogen. Transportation and storage and carbon capture and sequestration have given us pause as an organization and we looked to PHMSA R&D program to help face these potential challenges… next slide, please.

When looking at how things are R&D program can help address some of the public priorities and challenges. It's important to first look at the mission of the program. And so you can see here, the vision is to support PHMSA's mission to protect people in the environment from the risks inherent in transportation of hazardous materials and the mission of the R&D program is to sponsor research and development projects focused on providing near term solutions that will improve the safety reduce environmental impact and enhance the reliability of the nation's Pipeline transportation system…next slide, please.

As a safety advocate, I admittedly recoil when I think of the highly explosive. If that's a word that is hydrogen and so our questions that we looked at the R&D program to address are very simple how and if it can be transported safely. How can it be produced and transported in a way that truly lowers greenhouse gas emissions and how can those full cycle greenhouse gas emissions be measured? Next slide.

And while carbon capture and sequestration didn't give us that same primal aversion as hydrogen events such as the denbury failure and satartia, Mississippi gave us equal pause and lead us to similar questions as hydrogen again. How can it be transported safely? How can it be captured transported and stored in a way that significantly lowers greenhouse gas emissions? How can the full life cycle emissions be measured and also want to state that enhanced oil recovery should not be a priority of any publicly funded CCS R&D.

With both hydrogen and carbon capture and sequestration, our perspective is let's be crystal clear on any added safety risks. We are adding our communities to take on with these technologies and let's be just as clear on exactly what greenhouse gas emission reductions we would be receiving. Next slide please.

Methane mitigation is one of those issues that is squarely in the safety and climate intersection of the Venn diagram and remains a huge priority for us. We recognize that this is an area rich with R&D opportunities, and I just included a couple that we would love to see the R&D program address exploring the full range of technologies available to eliminate plan venting and Blowdowns and how can an operator determine the appropriate mix of tools to find leaks on their systems? Next slide please.

I know the focus of this forum is hydrogen and alternative fuels, but I do want to take a moment to share another priority that the pipeline safety trust would love to see addressed. With the welcome emphasis on public awareness and public engagement by the industry and its regulators, we believe there remains a large knowledge gap that could be addressed by social science. We know that it is extremely difficult to effectively communicate risk for example, Social Science R&D could help the industry and its regulators be better at communicating risk at making the public aware of the pipelines in their communities and that effectively engaging with stakeholders and rights holders. Also, we recognize that an effective R&D program needs to have full active engagement from the industry. It's essential. But we would also like to see an increased role from academia and setting priorities and doing this work. And next slide.

And that's it for this nonscientist and an engineer. Thank you again for inviting me to participate today and allowing me to express our priorities and concerns and how this program can address them. You can see my contact information here, so please reach out if you would ever like to discuss any of this further.

White, Sentho (PHMSA)
Alright and thank you Bill and thank you for all the work that the trust does in advocating for pipeline public safety. And with that, now we're going to open it up to our participants to see if you all have any questions for our 2 panelists and so I'm going to send that over to Nathan and to ask if we have any questions from the audience in our chat feature.

Schoenkin, Nathan (PHMSA)
Great, thanks, if anybody would like to ask a question, please enter your question in the meeting chat and then we will route it to the appropriate person.

OK, we have our first question from Joseph Feldman. You mentioned how hydrogen can be an indirect greenhouse gas, but can it also negatively affect the ozone layer. Let's pass it over to Steve if you don't mind.

Steven Hamburg
Ah that's a great question, I don't have… I'm not positive the answers. So, I'm actually going to go back to the research. I'm not an atmosphere chemist. So I apologize for that.

In terms of the ozone layer, I don't believe so but I don't feel confident enough. I shouldn't even have said that without checking with my atmosphere chemist colleagues.

Schoenkin, Nathan (PHMSA)
Alright, thanks Steve I appreciate that all right, and any other questions.

OK, next question the first presenter mentioned that there was a data problem. I'm wondering if the data we are looking at looking for is truly unavailable or is it simply limited.

Steven Hamburg
So I think it's both so for example, on the distribution of pipe types. That data is available. We have been able to get it from individual utilities, but it is not reported to PHMSA as far as I know or it's not reported out by PHMSA. I'll defer to the PHMSA folks.

And yet that information exists or we hope most of the utilities have it because it's very hard to manage pipes. If you don't understand what you have; I'm assuming most of them have fairly good Maps, though I realized there's been translation problems of going digital? And then there's of course, the issue of actually taking enough measurements to understand patterns of leak indications and in turn quantification of leaks that data is not as robust as it could be, but we know how to collect it now, so I think what we really need to think is what kind of data do we really need to have in order to make the most informed decisions and then both either make that data transparent, and where does it exist and collect it. Or it doesn't exist and certainly in the case of things like hydrogen, we do not have the data. At least not that we can find and we're not at war by a long shot. The data doesn't exist. So we really need even though the number of miles is limited currently and it's not zero. So we should be looking at the existing infrastructure and then looking at additional testing and putting in miles of pipes and checking them out and artificially aging ET cetera ET cetera. I think there's lots of things we can do to learn a lot quicker to allow us to make better decisions.

Schoenkin, Nathan (PHMSA)
I think we have another question, does the presentation differentiate between bleed blue and green hydrogen. I imagine that might be to both panelists so who wants to start first?

Steven Hamburg
I'll just go ahead, yeah, so in terms of the hydrogen leak and no so there's hydrogen molecules of hydrogen molecule how it's formed is irrelevant in terms of the upstream formation absolutely in terms of the overall greenhouse gas impacts. It makes a big difference, there, of course, you have if you're using natural gas.

Schoenkin, Nathan (PHMSA)
Steve go ahead.

Steven Hamburg
Yes, I have to create blue hydrogen. The upstream emissions matters currently in the US. We have a highly diverse set of upstream emissions. They vary on the on the…

Hendricks \ John \ M
Yeah, they're just trying to add it to the 10% hydrogen or 5% hydrogen going into the gas stream.

Steven Hamburg
Well, those would matter.

Hendricks \ John \ M
Just make more environmentally friendly because it's going to burn into or turn into water when it combusts.

Schoenkin, Nathan (PHMSA)
Sorry. If we don't mind let's keep going.

Hendricks \ John \ M
It does a little bit because it's so much lower than gas. Perfect.

Schoenkin, Nathan (PHMSA)
If we have any follow up on questions. I think it would be best to put it in the comments section just because with this being virtual will be a little hard to have a few folks talking.

Hendricks \ John \ M
So, like they could make it, either recoup from landfills or they can even take the natural gas and take the hydrogen off of it and crack it out.

Schoenkin, Nathan (PHMSA)
Alright, please proceed Steven.

Steven Hamburg
Well, I just was saying that I think that we do need to worry about the upstream emissions for the blue hydrogen and also of course the CO2 efficiency because you currently CCS is not 100%. Even on the best of circumstances and you do have to do the full accounting for all of that to understand the climate implications of blue hydrogen clearly with green hydrogen. The upstream will be much less if not zero but the hydrogen leakage still matters for both of those.

Bill Caram - Pipeline Safety Trust (Guest)
Yeah, and I don't have much to add there but those are the concerns, I was speaking of when talking about how do we really measure the full greenhouse gas emissions over the life cycle and let's be clear on the benefits we're receiving.

Schoenkin, Nathan (PHMSA)
Thank you Bill and thank you Steve and we have another question, the figures related to estimate emissions you presented are troubling do you know how the emissions report defensor compares to what this work estimates for emissions? Are there obvious reasons why there might be such wide gaps.

Steven Hamburg
I actually don't know the PHMSA are reporting numbers well enough, so I'm going to defer to others at PHMSA. We used indirect empirical data, not reported numbers. I apologize I don't know that comparison number, but the original numbers so when we compared it EPA. Those are not PHMSA numbers. Those come from these earlier studies that I described so as far as I know. None of the national reporting of methane emissions is based on PHMSA numbers but again, I'll defer to folks in PHMSA to tell me that in fact. That's not true but I'm pretty sure that's true for the inventory that EPA generates relative to US greenhouse gas emissions.

Schoenkin, Nathan (PHMSA)
Alright thanks Steven and Sentho before I over speak here do you have any thoughts on that.

White, Sentho (PHMSA)
We do collect certain reporting data from the pipeline operators. I don't actually know them off the top of my head, but I could definitely provide in the chat the specific regulations that provides the reporting requirements for pipeline operators.

Schoenkin, Nathan (PHMSA)
Alright thanks, Sentho.

OK, one more question here, is there an expected funding stream for the infrastructure bill that will support PHMSA goals and objectives mentioned by the presenters.

This one we might pass over to Sentho or Massoud if you're on the line.

White, Sentho (PHMSA)
Sure, Massoud are you on the line otherwise I can go ahead and take a stab at that one.

Tahamtani, Massoud (PHMSA)
Good morning, everybody, I'm on the line.Sentho go ahead.

White, Sentho (PHMSA)
So with the passing of the bipartisan infrastructure law, we did receive funding for at least about one billion dollars of grant funding for cast iron repair and rehabilitation so all of that. We currently believe are going to have not all of it at once, but 195,000,000 if I'm not mistaken for this first year and so we're in the process, not deferred on how we're going to be addressing that apportionment.

Tahamtani, Massoud (PHMSA)
OK, like you said it's about 200,000,000.00, a year for the next 5 years. But after taking some of the administrative costs out of it, it's about 195,000,000.00, a year. And it is to go and replace basically older pipelines within municipal systems.

I want to go back to a question that was asked about methane released that are reported to PHSMA. We get methane release data with accident data. Not all the methane release, though

out there, none methane in a meeting with leaks for example, but if there's an accident and it's reportable under the code then the methane releases report to us.

Schoenkin, Nathan (PHMSA)
Alright thank you Massoud. Alright, we have a next question, and just for everybody's awareness will probably have enough time for another 3 questions so they're probably already written on the board here so from Hillary: What would you recommend for public education on hydrogen and carbon capture potential since they're relatively less known technologies?

Bill Caram - Pipeline Safety Trust (Guest)
Yeah, I mean, we're kind of starting at zero with the public here and so I know with some of the carbon capture CO2 lines that are starting to be planned in the Midwest. There's a lot of fear here and uncertainty and so I think we need to start very basic and we're really starting with zero with the public and as Stephen pointed out there's still a lot for the experts to learn too.

Schoenkin, Nathan (PHMSA)
Alright Thanks Bill, and Steve and go ahead.

Steven Hamburg
Yeah, I would just echo that I think you know, we all need to learn together. We need to understand what people do understand and what they don't and then work to learn more and do that, and collaborative way with communities across the US so that we can collectively come with a good set of solutions for the decarbonized economy that both meets the energy needs and the needs of communities and I think we don't at least I'm not aware that we really have the data on understanding what everyone thinks they know what they know they don't know, and where the gaps are from a multitude of perspectives.

Schoenkin, Nathan (PHMSA)
Alright. Thank you, Bill, and thank you Steven. So, next question from Shawnee: The detectable leak sizes getting smaller due to detectability could that explain the discrepancy in numbers and back to Steven and bill if you would like to say something feel free if not, please say pass and you know, we can continue that way.

Steven Hamburg
Yeah, so absolutely that's a key part of it, but it's not all of it. So, they're not all of the missed leak indications are because they're small that is a large part of it, but they add up 2 small ones, which is one of the sometimes misperceptions that small ones don't matter they are less of a safety concern, which is great, so they're not low concentrations won't build up to the point that they're representing a safety hazard, but they do add up. And so yes, it's partially the better technologies allowed us to get a better handle on the full distribution of emissions. But it's not exclusively from smaller ones. It's also the fact that given winds and other urban real life conditions that better detectability allows us pick up some of the larger sources as well that we're getting missed otherwise.

Bill Caram - Pipeline Safety Trust (Guest)
And I don't have anything to add to Stevens Great answer.

Schoenkin, Nathan (PHMSA)
OK sounds good. Alright next question comes from George: How is theft measurement error and leakage downstream of the meter factored into the emission numbers?

Steven Hamburg
They currently are not so this is the problem I described for Boston. As we currently do not have good estimates now when we measure. Certainly the ways that we described with the using this joint project with Google with the streetcars. We can't always tell whether it's which side of the shut off valve. It is we usually know which side of the meter. It is, but not the shut off valve so sometimes it isn't the service entrance and it shows up, but we don't know what those numbers are and we're seeing similar things from data. That's emerging out of Europe. There's the unknown. We have a series of studies by a different group of series of researchers have looked at the boiler efficiency and hot water and pipes and all kinds of things and the bottom line is we can't explain what we see in the air over a city versus what we can measure bottom up from different components of the system.

That's where the gap is we need a lot more effort, there to really understand what's going on and we did. As I mentioned briefly. We do see that there's clearly some leakage that gets into sewers. We had a started assuming that that was biogenic methane. But in fact at least in the places we've looked it's been dominated by thermogenic methane with ethane methane ratio is consistent with the pipeline gas so and that's not totally surprising when you think about it. It's a path of less resistance so if it is in the soil and you've got a sewer.That has some permeability and the old cities like Boston or where I am in Providence, where you've got a lot of brick pipe etc. Then the gas in and it comes out of the out of the sewer hatches.

Schoenkin, Nathan (PHMSA)
Alright. Thank you Steve.

Schoenkin, Nathan (PHMSA)
OK alright I will be putting into the chat in a few moments here the reporting requirements for releases if anybody would like to go take a look at them, they'll be copied into the chat and we are going a little bit faster than I expected. So we have some more time for a few more questions. If people have. But I will read out the next question here. Sentho do you have something to add?

White, Sentho (PHMSA)
No, I just had a question as well, but let's go ahead first Nathan.

Schoenkin, Nathan (PHMSA)
OK alright this is from a Weldon: while the safety of transporting hydrogen through existing pipelines is clearly the current focus. There will be many required changes to the standards equipment and systems that support transporting and measuring hydrogen in our existing pipelines. This includes software systems such as SCADA and flow. Computers will there be funding for the systems that will support our pipelines.

So I believe that would probably be geared towards PHMSA. I could be wrong, Massoud?

Tahamtani, Massoud (PHMSA)
I think that is geared toward us. And we need to simply find the answer to that question and post it.

Schoenkin, Nathan (PHMSA)
I would agree OK Alright Thanks Missoud. Sentho would you like to ask your question or?

White, Sentho (PHMSA)
Sure, Yep and I've got a question for Bill so this event. Obviously is discussing you know different emerging fuels and from your perspective, which emerging fuels transported by pipeline would create the most safety challenges to the public.

Bill Caram - Pipeline Safety Trust (Guest)
I would say probably hydrogen gives us the most pause and that's exactly why we have this R&D program to try to figure out how to do it safely if it can be done safely. I would say hydrogen gives us the most cause of concern and from a safety perspective.

White, Sentho (PHMSA)
Thank you and what advocacy measures is your organization taking to raise and address awareness to those concerns.

Bill Caram - Pipeline Safety Trust (Guest)
Really just education, but first we have to learn and so we're trying to learn both on hydrogen and on carbon capture and sequestration as much as we can and try to appropriately communicate the risks and benefits to the members of the public.

White, Sentho (PHMSA)
Alright, thank you. Nathan do we have any other questions in the chat?

Schoenkin, Nathan (PHMSA)
We do not. I will open it up for one more. Well, actually we just got one more question from Erin Murphy would like to ask: your recommendation to fund social Sciences research seems important could such research contribute to improving equity in pipeline safety.

Bill Caram - Pipeline Safety Trust (Guest)
Absolutely and we would love to see a specific focus there on that type of funding. It's not huge potential therefore, making a lot of progress it's been ignored for far too long and there's just ripe areas for a better engagement with these underserved communities and I would build off that because we actually have done when we did our mapping. We did do social science research social psychology. Research is set of experiments to understand how people perceived it because we didn't want to cause anxiety because if there were any safety leaks that we measured we of course immediately called it in and made sure it got addressed on any map. We put out wasn't in a safety immediate safety concern. It was so we did a lot of testing that totally changed how we presented the data, and I readily say to my team and said in public. My thoughts of how we should do it. We're all wrong and we used the social psychology work and the experiments,

meaning just testing how people responded different things as a basis for ensuring that we could be positive in our message and ensure that people understood what the data, said, and what it didn't say obviously it's up to them to how they want to view it in terms of action. But I totally endorse the criticality of that which is why I think the earlier question. It's so important that we learned together across communities what these represent because it isn't one universal response there. There is a lot of variability across different communities and how they perceive and address these issues.

Schoenkin, Nathan (PHMSA)
Alright thank you. We had one additional question. But I think it's about what will be covered later during this seminar and that might be covered during the interagency panel so Sentho would you like to proceed?

White, Sentho (PHMSA)
Sure. So that concludes our open Q&A. Just like to thank both presenters. Stephen and Bill for their great and informative presentations. Today, as well as their responses to the questions that were posed by the participants in the forum. Again, I think it's been a very exciting start to our R&D forum, so with that I will turn it back over to Bob.

Smith, Robert (PHMSA)
Well, thank you. Sentho that was fantastic, some really good information in there and I'm really glad to see that exchange of an interesting questions and answers also like to thank of course, Stephen and Bill for that and panelists and panel 2 interagency partners, please be ready to unmute yourself when called upon let me go ahead and share the next presentation.

Schoenkin, Nathan (PHMSA)
And Bob just quickly while you're at that time, I believe we have one individual from DOE that called in on their phone. Can you please make sure you can unmute yourself?
OK, so it's now transitioned to panel 2. Let me introduce Kandi Barakat, who is one of 2 operations supervisors for the engineering and research division within PHMSA Office of pipeline safety Kandi will moderate this panel and the Q&A session following the panel Kandi can we go ahead and proceed.

Barakat, Kandilarya (PHMSA)
Good morning or good afternoon, everyone it is my pleasure to be here today and moderate our panel and look forward to hearing the presentations from our interagency partners. The panel two objective is to learn from the presenters about what research and policy measures our interagency partners are taking to address emerging fuels, including hydrogen and climate change challenges with respect to pipelines this panel has 4 presenters. Our first presenter is Timothy Reinhart, director of oil, gas supply and delivery at the Department of Energy 's Office of fossil energy. Timothy will be sharing the activities by the DOJ office of fossil energy in support of this panels objective. Timothy please proceed with your presentation.

Timothy
Great thank you. Kandi, first off can you hear me?

Barakat, Kandilarya (PHMSA)
Yes, I can.

Timothy
OK, great, so good morning, and thank you all for the opportunity to speak at this event. As mentioned, I'm Tim Rinehart. The director for what is now actually the division of methane mitigation technologies. It was formerly the division of supply and delivery which is within the office of resource sustainability, which also again was until recently known as the office of oil and natural gas.

Yes, within fossil energy and carbon management also known as EBM here at DIA. I'll be speaking to our efforts largely in methane mitigation and quantification technologies as well as our newer efforts in natural gas decarbonization and hydrogen technologies next slide, please.

So here is a quick overview of the new fossil energy and Carbon Management Office of resource sustainability, organizational chart. We don't have to indigo a lot of detail here, but it also illustrates some of the administration 's high level goals as well as the office is new mission, which is to design administer activities associated with technologies and approaches that will reduce environmental impacts of our continued use of coal oil and natural gas and so we seek to accomplish these goals through Policy Research innovation outreach and stewardship. Next slide please.

So FPCM envisions itself as an organization that works to minimize the client at climate rather and environmental impacts of fossil energy and advances carbon management to make significant contributions to achieving the nation 's energy goals.This approach will help SCCM to serve as a global leader for maintaining environmental stewardship while enhancing America's economy. So the FPCM mission is central to our nation 's efforts to minimize the environmental impacts of fossil fuels. So FPCM will use research development demonstration and deployment approaches to advanced technologies to reduce carbon emissions and other environmental impacts of fossil fuel production and use. Predictable, particularly committed emissions in the electricity sector and hard to decarbonize emissions in the industrial sectors. Some priority areas of technology work include point source carbon capture hydrogen and methane emissions reductions, which will be specifically focusing in on today as well as critical mineral production and carbon dioxide removal next slide, please.

So turning back to the office of resource sustainable sustainability again. Formerly the office of oil and natural gas. The current program areas are shown here will be paying particular attention to really the top 2 areas shown on this chart. So methane mitigation R&D efforts include advanced materials of construction monitoring sensors data management systems in more efficient and flexible compressor stations. We're also working on creating innovative solutions to reduce associated gas flaring and venting including alternative uses for the stranded natural gas through modular technologies designed to convert the gas to higher value solid and liquid products that can be transported more efficient. In addition, modular conversion technologies that's designed to generate hydrogen as a clean distributed energy carrier are also being pursued.

And then as part of that in natural gas decarbonization and hydrogen research which is our newest program. But it's still really in the form that stages. We seek transformational concepts for decarbonization agenda clean hydrogen from domestic natural gas resources. We also seek to identify rather underground storage as well as assess and ensure the suitability of existing natural gas pipelines for Hydrogen Utilization. Next slide please.
In the area, or the arena of methane emissions and you've seen and heard this largely before. This is largely EPA data. But the figure on the left shows the distribution of EPA emission investments across the oil and natural gas supply chain by life cycle stage. The bulk of the emissions as you can see more than 2/3 or around 132,000,000 metric tons of CO2 equivalent comes from the upstream production portion of this might change. The figure on the right shows the distribution of emission sources within the production sector 4, 2019 data. EPA estimates that approximately 25.4 1,000,000 Metric tons of CO2 equivalent or is emitted during the flowering of associated gas during oil production and another 7.9, 1,000,000 metric tons of CO2 equivalent from other miscellaneous flaring activities. However, the primary sources of methane emissions from oil and gas production are attributed to pneumatic controllers these are the debts pressure driven valve controllers designed to really small amounts of methane during normal gas control operation, e.g. valve opening and closing activities. Natural gas gathering in boosting stations are the second leading cause of methane emissions associated with natural gas oil and production. Turning towards natural gas processing transmission and storage as well as gas distribution sectors account for a relatively small portion of overall methane emissions. The primary sources of emissions within processing and transmission or from Compressors and their associated engines while within the distribution sector has that's already been talked to at some length. The primary sources of emissions are actually from lined lakes themselves as well as meter. Next slide, please.

So as a response to this with India, we uh the research program is mitigating methane emissions across the supply chain with work in areas such as production again. Do include venting and flaring gathering lines. Pipelines components certainly to include pneumatic controllers compressors meters engines, etc. But due to the distributed nature of these point sources. The office is focused on developing accurate cost effective and efficient technologies solutions and best practices to identify measure monitor and eliminate methane emissions from these sources, so the research program qualifies emissions from these same parts of the supply chain areas of research can really be broken down into several research categories, based upon the prime function of the various technologies, so within sensing leaps, obviously developing sensors to help with those leak detection 's in quantifying leaks. Being able to measure volume and rates of those leaks in minimizing leaks developing technologies to monitor and detect pipeline cracks and corrosion 's as well as developing liners and coatings to prevent those leaks and then when it comes to predicting deletes we're using AI. Artificial intelligence and machine learning to analyze data health to help us predict and prevent leaks before they occur fixing leaks again developing technologies. To repair in situ issues, that they occur and then we also have leaked type components that consist of developing their retrofitting compressors pneumatic controllers valves, etc to reduce or eliminate those links. We also go out and validate technologies. So we're field verifying new technology new technologies. Rather, at the DMV test side at Colorado State University and so we're working on creating innovative solutions to reduce associated gate up gas flaring inventing as well, including as I had mentioned alternative uses for the stranded natural gas through those modular technologies and then finally in one of our most recent

developments were developing cost effective technologies and methods for locating quantifying and prioritizing orphaned and abandoned oil and gas wells for cost effective plugging ultimately next slide, please.

So research efforts for methane emissions quantification focus on developing technologies to detect locate and measure emissions. This includes the development invalidation of measurement sensor technologies for the collection dissemination and analysis of emission data, which will inform efforts such as the greenhouse. Gas inventory from EPA and orphan well remediation programs, which respectively code. Both EPA and the Department of interior as well as other interested stakeholders next slide, please.

SCCM and the National Energy Technology Laboratory or any TL are working to advance methane emission. Quantification research through validation of the performance of new technologies to better measure and understand emissions derived from the natural gas supply chain. Many of the current barriers to adoption of new technologies rather related to emissions monitoring and quantification could partially be overcome by any tales data gathering efforts and collaboration with industry and academia and analysis of multiple datasets from various sources and time frames. Similarly, understanding the differences between natural gas transportation systems within the industry could provide a framework to develop specific methane emissions and mitigation quantification mitigation methods rather. Next slide please.

And so moving on to the nascent natural gas decarbonization and hydrogen technologies program. This area really seeks to develop as I've mentioned transformational technologies for decarbonized clean hydrogen from domestic natural gas sources. We're looking to identify underground storage infrastructure to handle large volumes of hydrogen. In mixed gases with large hydrogen fractions and then finally and has been mentioned in previous talks. We're really looking to ensure the suitability. And so finally we're looking to ensure the suitability of existing technologies within natural gas pipelines and infrastructure for Hydrogen Transport. Next slide please.

So do you win or partners must develop technologies that improve the cost and performance of hydrogen natural gas planned or otherwise known as high blend transportation infrastructure, including pipelines compression stations on a hydrogen separation technologies and systems analysis specific. R&D needs in this area will include lower costs and more reliable systems for distributing and dispensing hydrogen advanced technologies and concepts for hydrogen distribution, including liquefaction and material based chemical carriers. And then looking at rights of way permitting and reduced investment risk of deploying delivery infrastructure or utilizing existing natural gas infrastructure. So to capitalize on any benefits of high blender hydrogen transport systems leaks and efficient operations are critical as Ben has been mentioned previously to mitigate both greenhouse gas, and other emissions from that supply chain. Next slide please.

The first step we're considering is using natural gas infrastructure with hydrogen is really likely to be blending hydrogen and the existing natural gas pipeline system. Information in the box on the right highlights some of the differences between hydrogen natural gas and blended gases. Primary considerations, including material compatibility have natural gas pipeline materials with

hydrogen and the operations of those pipeline systems. Depending on the end use need blending it up to about 20% hydrogen on a volume basis is likely feasible in the majority of existing pipeline infrastructure, but again when you start talking about distribution lines and using either better steel or iron that number would obviously be lower. And as hydrogen usage increases dedicated pipelines for hydrogen or likely needed due to operational and safety considerations. So when the US just for comparison, that are currently about 1600 miles a little bit less have dedicated hydrogen pipelines, which tends to be stainless steel, mostly in mainland the Gulf Coast region while hydrogen is used in petrochemical production. This compares to the over 300,000 miles of existing natural gas transmission pipelines and over 1,000,000 miles of existing distribution pipelines again showing the large increase in dedicated or suitable hydrogen pipelines that will be needed to Dicarbonate Decarbonized. Rather, US power generation and heavy industry. Next slide please.

So, in in support of this new FPCM or fossil energy and carbon management project titled Subsurface Hydrogen assessment storage and technology a seller acceleration otherwise known to Shasta will assess and address the operational risks associated with reservoir storage. FPCM will leverage the unique capabilities and expertise have been national laboratories, the NHL Pacific Northwest and Lawrence. Livermore national laboratories, specifically to determine the viability safety and reliability of storing pure hydrogen or hydrogen natural gas blends in subsurface environments. Next slide please.

Suggested will address several critical questions for subsurface storage that need to be answered. The project will determine the technical feasibility of hydrogen storage and subsurface systems and quantify the operational risks associated with storage and those systems. It will also develop technologies and tools that will help to bring disk or reduce or minimize those risks. As hydrogen storage potentially ramps up insights from the natural gas storage and existing facilities. We believe will be needed to demonstrate safe and effective operations into the future. Ultimately, we hope to develop a scientifically informed field test plan to reduce any remaining uncertainties in system performance. Next slide.

So these and other efforts helped and the office of resource sustainability again move toward our goal of reducing the impact of continued use of coal oil and natural gas in helping to enable a hydrogen or hydrogen based economy. Moving forward that is all I have, but thank you all very much.

Barakat, Kandilarya (PHMSA)
Thank you Timothy for this informative presentation our next presenter is Mark Richards Technology manager at the Department of Energy 's Office of energy efficiency and renewable energy. Mark will be sharing the activities by the DOE Office of fossil energy in support of this panels objective. Mark please proceed with your presentation.

Mark Richards (DOE) (Guest)
I'd like to thank them for inviting me to participate in this R&D form. I am a technology manager and the hydrogen and fuel cell technologies office within ERE. I'm personally focusing on hydrogen infrastructure. I've been with DOE for about 2 years. But I've worked for over 20 years

in alternative energy technology development across both natural gas and hydrogen both with commercial technology Developers and R&D institutions. Next slide.

Mark Richards (DOE) (Guest)
Earlier this year, the Biden ministration charged with accelerating technology development to help address climate change. And this charge is reflected in ERE mission statement, which with emphasis on reducing greenhouse gas emissions to net zero by 2050 not creating jobs and ensuring equity and environmental justice. Next.

Reaching net zero greenhouse gas emissions. Obviously will be a considerable challenge and you can see here that and the breakdown of primary energy consumption in the USA. Fossil fuels here petroleum natural gas and coal represent approximately 80% of total energy consumption. Next, please.

So where does hydrogen play a role in achieving greenhouse gas reduction targets. Now H2 at scale is one of the ERE key initiatives to enable large scale production storage and utilization of hydrogen for specific applications across various sectors. Hydrogen can be produced from a number of resources, resulting in a variety of hydrogen colors, which you may have encountered. For instance, electricity from renewables such as wind and solar used via electrolysis results in green hydrogen and natural gas. Yes, VST methane reforming followed by carbon capture and sequestration results in blue hydrogen. I think there's about 6 or 7 other different colors of hydrogen, but that's just providing an example of some of the things that are out there. Many of those sectors on the right side of the graphic are particularly difficult to do to decarbonize such as heavy-duty transportation industrial processes such as a steel manufacturing. I'm at the lower right to give you a sense of scale about 10,000,000 metric tons of hydrogen are produced annually in the US if we were to double it demand for hydrogen. That could require approximately doubling today's wind and solar capacity were all the additional hydrogen produced from these energy sources via electrolysis. Next.

The hydrogen program at DOE is not limited to ERE the graphic in the center of the chart outlines the officers involved in DOE hydrogen program, including ERE. Fossil energy and carbon management nuclear energy. The Office of electricity, RP and the office of science. Late last year, a deal, we updated the departments hydrogen program plan, which is available online. The program plans main priorities include reducing the cost of clean hydrogen, ensuring safe and efficient hydrogen delivery and storage and enabling large scale end use applications while working on these priorities. We need to also address equity in environmental justice safety and workforce development. Next, please.

So how can hydrogen be competitive with existing resources? Analysis have indicated that to address particularly hard to decarbonize sectors. We need to approach a large-scale hydrogen cost of $1.00 per kilogram. Earlier this year deal, we launched the hydrogen energy earth shot with this goal of achieving the cost of a dollar per kilogram of clean hydrogen within one decade. Last August, a summit was held to kick off this effort and engage with stakeholders. Information from the summit should be available online in the near future. So how do we get to a dollar per kilogram of hydrogen on the left side you'll notice that the cost of electricity? Is a substantial component of the cost of electrolytic hydrogen. Other factors also need to be addressed,

including increasing conversion efficiency, reducing capital costs. Improving durability and life and reaching manufacturing scale for these conversion technologies. The table lists some intermediate goals for both low temperature listed here as pem as an example. There are other low temperature technologies as well as high temperature example here being solid oxide electrolyzers. Pem electrolyzers of low temperature electrolyzers in general are typically higher TRL. So then technologies such as solid oxide. Next, please.
In terms of efforts that relate directly or more directly to pipelines. I'd like to highlight 2 areas of activity, the first is the recently launched high blend initiative. It's first ever got underway earlier this year as a cooperative project across 6 national labs and about 30 industry stakeholders. This effort will assess the feasibility of blending hydrogen into the natural gas grid and focus on 4 areas related to blending. The first is an updated literature review of the global research and experience of operating hydrogen blends. Second is a polymeric material compatibility, including crack growth assessment in medium and high density polyethylene. Assessments of the impacts of polymer additives and contaminants on fracture initiation. Assessment of the impact of blends on creep and pipeline joints and at points of localized stress and development of stress rupture curves for polymers and blends. Third is the development of a publicly available model that will use a probabilistic framework to assess pipeline integrity and blends that and that will inform pipeline operation and maintenance inputs to be incorporated in the model will be blend concentration pipeline material of construction impurities in natural gas and existing defect populations in pipeline materials. And last our analysis to characterize the life cycle emission impacts of blends. The variables being considered include pathway energy efficiency greenhouse gas emissions criteria pollutants. The impacts of leakage and impacts of new pipeline. Construction relative to adaptation of existing lines also techno economic analysis will assess grid integrated electrolysis scenarios with a model of pipeline construction to estimate the cost and value proposition of blending in various the user defined scenarios. Next.

The second pipeline related activity area is the hydrogen materials compatibility consortium or H map. This was launched in 2018 and encompasses national labs and teams from industry and academia. Hmat focuses on increasing the life of materials in hydrogen environments. These materials include metals for both storage and pipeline systems polymers to date. This had been particularly focused on seals and novel material development. Some work related to assessing the performance of pipeline materials and hydrogen blends will be done within this consortium in support of the high blend initiative and there is more information on HMat can be found at the link that appears at the lower center of the slide. Next, please.

And I'd like to wrap up with some possible areas where gaps may exist in, where collaboration could be beneficial. Now these items, obviously not exhaustive and all-inclusive but representative have come from industry and other stakeholders. Aside from material compatibility, which we've already discussed to some extent, there are a number of questions related to the sustainability or the suitability. Of traditional natural gas detection approaches in a blended environment. Changes in flammability characteristics with blends could affect how electrical components need to be designed or classified and additionally a number of operational concerns need to be assessed as inspection and maintenance practices may need adaptation in a blended environment. Next, please.

For additional information, I've included some links here for those in the hydrogen network

components. Working group tomorrow at my colleague may or stogi will be going into more depth regarding some of what I briefly covered today and I'd also like to mention that on December 8th at noon Eastern Hydrogen program will be providing an overview of the hydrogen provisions in by parts and infrastructure law, which includes 8 billion dollars for regional clean hydrogen hubs and one and a half billion dollars for electrolysis and clean hydrogen manufacturing and recycling RD&D. That's all I have thank you for your attention.

Barakat, Kandilarya (PHMSA)
Thank you mark. Our 3rd presenter is Andy Miller Associate Director for climate at the Environmental Protection Agency and they will be sharing the activities by the EPA in support of this panel's objective. Andy please proceed with your presentation.

Miller, Andy
Thank you Kandi can you hear me OK?

Barakat, Kandilarya (PHMSA)
Yes, I can.

Miller, Andy
OK, great. Thank you so thank you. Thanks to Bob thanks to PHMSA for the opportunity to talk with you today and provide a bit of background information about EPA and our interest in pipeline transport and emerging fuels. So, my focus is going to be more on the research issues. I'm in EPA 's research office, so I'm not going to discuss regulatory issues in any kind of detail. I'll certainly point out how regulations affect the need for technical information and research, next slide, please.

So the overall mission of EPA is to protect human health and the environment. I think most everybody knows that EPA develops and enforces environmental regulations. But we do quite a bit more than that, we give grants to States and cities. We do research on environmental issues related to EPA 's mission. We sponsor voluntary partnerships and I'll talk about that here in a bit. We teach the public about environmental issues. We publish information about environmental performance impacts and science and I'll talk mostly today about the emission inventories are partnership programs and our research activities. So we're a relatively small agency. We have about 14,000 people across 4 main regulatory offices, one for air one for water one for land and one for chemicals and we have 10 regional offices. Our budget is about 50% grants to States and others for water treatment infrastructure waste management air monitoring and other state level environmental activities. Our research office has about 1500 people and a budget of about 500 $1,000,000.00. So it's not tiny, but it's a relatively small research presence next slide, please.

So a quick introduction to some of the key activities were doing related to pipelines and emerging fuels. The first is all I'll just mention. The proposed rule is out to reduce methane emissions from oil and gas operations. This obviously is we've heard of drives and need to quantify those emissions so that is one area that I'll talk about in more detail the second. Activity related to the regulatory side is the groundwater protection regulations, which cover underground injection of carbon dioxide. These are the classics well rules that that many of you may know about in terms of geological sequestration of CO2.

In the next few slides I'll talk more about quantifying air pollutant emissions. Development of the inventories about our partnership programs that include Energy Star. The Green Power Partnership Heat Island reduction program. Smartway transport partnership and a host of others that really are intended to help people connect and learn from one another. And also talk more about some of the research work that we're doing related to emission measurements and evaluating the impacts of emissions. Next slide please.
So we've heard already some of the discussion of inventories. EPA has the responsibility to quantify emissions of air pollutants at a national level by pollutant and by source category and these include sulfur dioxide nitrogen oxides carbon monoxide particulate matter. Ozone precursors, which include volatile organic compounds and inventories of hazardous air pollutants. Now we're also responsible for developing and submitting to the UN Framework Convention on climate change and National Inventory of greenhouse gas emissions and here I'll talk mostly about CO2 and methane, which are the largest emitters of greenhouse gases by mass and by climate impact. Next slide please.

So our voluntary partnership programs are sponsored by EPA because we feel like they are an excellent way to provide information to participants about technologies about methods. They provide venues to exchange information about best practices and to recognize members achievements and relative to methane. There are a number of these there's one for Agriculture, one for coalbed methane. There is one that that goes that that addresses international emissions so that the global machine methane initiative. There's a landfill methane outreach program and probably most relevant to the to the audience. Here is the voluntary methane programs for the oil and gas industry. That includes the natural gas star program and there is a link there at the bottom that you can take to find out more about these programs and to sign up if you aren't already part of that that effort. Next slide please.

So EPA has had an interest in understanding methane emissions for quite some time. That's obviously now and administration priority our concerns are related to oil and gas production among others, and as we've already heard there's a range of sources of methane from these processes in the ranging from the primary production to processing and transport.

These include compressors fugitive emissions and pneumatic controllers as DOE presented in storage vessels. We have concern about leaks about major events such as we saw with the Aliso Canyon event. And although it's not a major issue here for this group. We're also interested in understanding methane emissions from landfills and other biological sources and part of the connection. There is that many of the measurement technologies and approaches that we use for looking at leaks and these other fugitive and stochastic emissions are very good for addressing methane from landfills and vice versa, so they all fit together and we also obviously have an interest in those pollutants that are CO2 emitted such as organic compounds hazardous air pollutants things like benzene or other toxics that that we're responsible to evaluate to report on and to understand the impacts of. Next slide please.

And as we've heard there is a rapidly increasing emphasis on CO2, particularly CO2 direct removal from the atmosphere. The use of carbon capture and storage. This leads us to a need for better information on emissions from pipeline transport and it's all of the steps associated with

that improved monitoring and verification at injection sites. How we do this to the kinds of technologies that we use how we would design a monitoring system? To evaluate leakage where we need to place sensors. These are all issues of research interest. We have not had a as strong a presence here as we've had over the past several years, but these are issues that we understand need more information better understanding of those kinds of details and that is an area where we're looking to increase our activities. We need better measurement and monitoring technologies in general, for both CO2 and methane and so by that I mean improved capabilities for remote, sensing and, especially at low concentrations improved capabilities to quantify emissions and improved emission mitigation strategies for both oil and gas operations for landfills for these area sources that are much more difficult to control than say a single stack. Where we have relatively steady rates of emissions, and we have a single point of emissions. Next slide please.

And as we just heard from DOE. There's a lot of growth lot of interest. Now in hydrogen and in particular as a transport fuel so how we see a lot of the application for hydrogen. Also, though for industry so there is a lot of uncertainty, though not just about the potential emissions at scale, but also the atmospheric chemistry consequences and we heard that earlier this morning, the same concerns were voiced there's a lot of uncertainty about this we do think that atmospheric hydrogen is likely to affect the chemistry in ways that could increase ozone. There's some evidence that increased hydrogen could affect the recovery rate of Stratospheric Ozone, although that concern seems to have is not as significant as it was in earlier years. There does seem to be some research that says that the impact on the Stratospheric Ozone Layer is not as high as originally thought and hydrogen may also facilitate as we heard earlier higher atmospheric methane levels. And so it's going to have these indirect climate impacts. Current thinking is that the impacts are going to be small in comparison to other greenhouse gases, particularly methane and CO2. But that conclusion is still uncertain so that's an area of research that that we see as important. Next slide please.

So we also conduct research to develop and evaluate air pollutant measurements or air pollutant emissions and the methods to measure those emissions. So our research efforts are generally focused on internal research within EPA by EPA staff and at relatively modest levels of investment. We have a strong interest in a strong track record in partnering and collaborating with industry with other research organizations and with other agencies and so this is an area where we hope to expand those collaborations and engagement and I think this is a good forum for us to make a lot of those connections are focus on methane is really on field studies to evaluate some of the methods that we've developed and others have developed taking those out into the field looking at how they perform under real world conditions here. UCR researchers taking measurements on a pneumatic controller. This is at a well pad in the Uinta Basin and we've done a fair amount of work in those in those areas and on and topics and look forward to continuing those kinds of activities. Next slide please.

So we see multiple opportunities for collaboration and coordination. These include quantifying emissions. We've heard a significant need for that, particularly emissions at low levels. How do we identify the sources? How do we quantify those overtime? How do we make sure that that the emissions that we're getting we're not a spike or that there were no it was not a low point? How do we do that over time and over these really broad spatial scales as well. How do we detect and

mitigate emissions from malfunctioning processes? You know the high emitters the Super emitters that may occur sporadically that may not be detected immediately. How do we detect those quickly? How do we address those and this has a lot of connections? Obviously with safety and leak detection more generally, we are interested in working to evaluate pipeline systems and transport systems as a whole. That includes the gathering networks to Compressors. The processing all of those components that feed together into the system. We want to take advantage of the synergies between leak monitoring for safety and monitoring for emissions and this is particularly true for methane that will also be very true as we transition to hydrogen the same kinds of issues are there and we hope that we can combine these efforts so that we're really addressing 2 issues at once. Both safety and the environmental side and obviously we're looking ahead to understand what the trends are related to CO2 transport to hydrogen production use scale up deployment. Those are our issues that are very, very hot right now. So how will they proceed in the future? What are the implications of? What are the potentials for that? That pathway for the energy system to take and what does that mean then for us and for the kinds of information that we need to provide internally and to others. So last slide, please.

So, in closing we feel that that the measurement needs are increasing rapidly and expanding. We need as we've heard higher resolution data both in time and in space we need to have better capability to quantify emissions at low levels of emissions and at low atmospheric concentrations. We need to be prepared for these changing targets of emissions of what is it that we need to measure and where so these are some of the challenges that we see for measurement needs, but we also are seeing capabilities that are increasing rapidly. So there's ubiquitous use now of sensors of drones. These are becoming cheaper more widely available. How do we use all of these data that we're collecting and then that others are collecting? How do we combine that in a way that really tells us what we need to know in order to respond and to for all of us to do our jobs. So, I'd like to thank everybody if for listening. If you have any questions, please feel free to send me a note. My email address is there, it's very simple miller.andy@epa.gov so Kandi, I'll turn it back over to you.

Barakat, Kandilarya (PHMSA)
Thank you Andy very much.

Miller, Andy
Thank you very much.

Barakat, Kandilarya (PHMSA)
Our 4th and final presenter is Matthew Connolly physicist in the applied chemicals division at the National Institute of standards and technology. Matthew will be sharing the nest research activities perspective in support of this panels objective Matthew please proceed with your presentation.

Connolly, Matthew J. (Fed)
Thank you and thank you for the invitation to hear this talk. So today, I'll be talking about the materials testing in hydrogen project through the National Institute of standards and technology. This is a large group then I'm recently taken over as project leader. So the materials testing in hydrogen project is part of the fatigue and fracture group of miss materials measurement

laboratory. The overarching NIST mission is to promote innovation and industrial competitiveness by advancing measurement science standards and technology in ways that enhance economic security and improve our quality of life. Under NIST as the materials Measurement Laboratory Merle specifically strives to establish relationships that result in advances with broad scientific impact and chemical biological and materials measurements and maintain this longstanding role as and reputation as a neutral partner so this neutral partner is a keyword here. While in this works with industrial industry partners and standards and code committees. NIST itself is a non-regulatory body. Also, the hydrogen testing is hydrogen materials testing in hydrogen project has 3 key components measurements modeling and science. Measurements include sorry. Thank you please go on to the next slide after this one.

Measurements include fracture tests as well as fatigue. Both pretty correct growth and fully reverse strain life tests and as well as my microscopy. These measurements feed into our modeling, which has largely been done to create accurate lifetime prediction models and update codes and standards. We are also striving to get at the underlying science around hydrogen and brittle meant through advanced correlated fractography and metallography neutron and synchrotron X Ray experiments tomography and looking at the effects of Isotope enrollment next slide, please.

The work that we do on measurements is largely for our industrial partners and other government agencies, including PHMSA, which has included Vanessa. The modeling has had a direct impact on code modifications. I'll discuss that later in the presentation and we published our science in high impact materials science journals next slide, please.

Or laboratory is located in Boulder, Colorado and well design and construction began. Some years prior actual materials testing in hydrogen gas began in 2012. The original investment was around $2,000,000.00 for lab and equipment and overall around 808.5, 1,000,000, has been invested since the start of this project. Some of this investment is necessary due to safety considerations for working with hydrogen. Gas these safety considerations for example, are why are testing facility is separated from our control room as you see in this image here now that's to help us keep electronics and spark sources away from hydrogen. Next slide please.

So as far as investments in our testing facility. We have 2 load frames for mechanical testing. One is 100 kilonewton and the other is 250 kilo, Newton capacity. Now we have 2 pressure vessels to use with these load frames. One is rated 238 MPA or 20,000 PSI and the other 234 MPA or 5000 PS. We primarily run fracture and strain life tests in the high-pressure chamber. Which is smaller and reserve are lower pressure chamber for fatigue crack growth rate measurements this lower pressure chamber for a 40 crack growth rate measurements is large enough to house our fatigue chain, which we have a patented and is capable of running 8 simultaneous fatigue crack growth rate tests next slide, please. So while this talked is primarily on our capabilities for testing in hydrogen gas. I do want to mention that NIST has a dedicated lab for testing materials resistance corrosion resistance to Supercritical CO2. Next slide please.

Another investment that we've made to really try and understand the effect of hydrogen on materials is to invest in this equipment, which is essentially moves are fracture and fatigue testing lab 2 neutron and synchrotron beamlines. This allows us to monitor the strain dislocation

density and void behavior as we mechanically test both in air and in hydrogen gas. Next slide please.

So as I mentioned we are key ongoing work. We're continuing work in measurements modeling and science. We are continuing on all of these things that are listed here, but specifically I'm going to discuss our strain life testing as well as our microscopy next slide, please. So we've recently developed the equipment necessary for running fully reversed strain life tests in high pressure hydrogen gas as these tests are fully reversed, meaning they go both intention and in compression. They're extremely difficult due to the alignment necessary for successful tests. As far as we are aware. We are the only facility capable of fully reversed strain life testing in high pressure hydrogen gas. Now, however, the data that we get from these tests ready huge amount of information allowing us to compare the elastic and plastic damage messed up manifestation in hydrogen gas versus air now. This is a very big for hydrogen testing as largely the impact is when the plastic damage is significant next slide, please.

Ongoing work related to our fracture and fatigue measurements is correlated fractography, which aims to relate fracture surfaces with metallography and the underlying damage mechanism. For example, in strain life. We observe fracture features which are more brittle in hydrogen compared to an error, suggesting different fracture processes. In addition, when we look at the microstructure before and after strain life tests. We see a large amount of grain reorientation for materials tested in air while we don't see this great orientation in hydrogen like your structure, it appears to be locked in by the hydrogen. So this suggests that the means, in which this material absorbs plastic damage is different in error compared to in hydrogen. Next slide please.

Our project has had enormous success in codes and standards work the first of which I'll mention is the SMEB 3112 by blind code. Previous versions of the code relied heavily on tensile tests in hydrogen since the effect of hydrogen on tensile properties increases with material strength. This lead to overly conservative designs for high strength materials. However, pipelines more often fail in fatigue and the same inverse relationship between strength and performance does not apply in fatigue as in tensile so missed collected a huge amount of data and thanks to this 8 specimen chain, allowing us to run multiple fatigue tests at once and we were successful in updating the code for higher strength materials based on fatigue next slide, please. In turn, these modifications as maybe 3112 save 29,000 pounds per mile pipeline for hydrogen service next slide, please.

Another success story is our work on the ISO 11114 dash 4 standard for pressure vessels. This standard has 3 tests for hydrogen service to choose from to sort of rank your materials for hydrogen service. Depending on which test you choose to run your results can be over or under conservative through our modeling efforts and informed by our strain life tests. We have developed a model which unifies these tests from the table developed here. One could relate one test of hydrogen performance with another through a normalization to the so called cumulative damage parameter slightly. So, in essence what we've done is to modify the unified the tests under the ISO 11114 dash 4 standard next slide, please.

Now so that's a bit about what we do at the NIST in terms of hydrogen and as well as seeing 2 corrosion measurements. I want to mention we heard a little bit about hydrogen blending. We

know that those hydrogen and natural gas blending is gaining interest worldwide. We've seen that initial tests on blending suggests just small amounts of hydrogen and methane could be sufficient to degrade pipeline and pressure vessels that's in methane, however, natural gas is not just methane so for future work we'd like to look at the significant impurities, which are in natural gas, which may impede or enhance. The effect of hydrogen so for example, oxygen is well known to impede these delirious effects of hydrogen. And whereas water can provide a new source of hydrogen and increase the effects of hydrogen embrittlement. So this needs to be studied. This this role that impurities have. We think that the first step to studying would need to be a survey of natural gas composition throughout the country and then next to systematically study the effect. These impurities have on hydrogen improvement. Both pipelines and pressure. With that I will thank you and here is the team that works on our hydrogen materials projected missed thank you.

Barakat, Kandilarya (PHMSA)
Thank you Matthew for this informative presentation and now let's move to the Q&A session for this panel. I believe we have few questions in the chat box already so Nathan I'll turn it to you to read out those questions.

Schoenkin, Nathan (PHMSA)
Great thanks Kandi, so before we start as we did in the last panel. I will read out the question and then we can go through the list of the 4 speakers and feel free to say pass if you have no comment on the first question is solely for Timothy Reinhardt at DOE. The question is, did he just say the office of oil and gas was renamed the office of sustainability? Do you mind just providing the name of your office again?

Timothy
I'm sorry that question was to me which was the office of oil and natural gas was renamed the office of resource sustainability. I lost you there for a second was there a second half to that question.

Schoenkin, Nathan (PHMSA)
No that that that was it. I think the individual here had office of sustainability. Can you read the title of your office out loud just so we can put it down?

Timothy
Yes, so at the sort of larger higher level, the office of fossil energy has become the office of fossil energy and carbon management and then for those of you who are familiar with the breakdown between the R&D offices within Fe Now FECM. It used to be Fe 20, which was the coal office there. Now the carbon management essentially office in FP 30, which used to be the office of oil and natural gas. We are now the office of the resource sustainability.

Schoenkin, Nathan (PHMSA)
OK alright thank you. Timothy alright so moving on we have another question from Gregory the question reads, I have realized that Green hydrogen keeps being used in discussion and presentations to my knowledge. There is virtually no green hydrogen being produced because the

Holy Grail for hydrogen production from wind or solar has not been found. Yet can someone define green hydrogen and make a statement about its production. Who would like to go first?

Mark Richards (DOE) (Guest)
I guess I should probably go first. There's various governmental organizations and regulatory organizations around the Globe, who are starting to put formal definitions to these things so. It does exist it's not nearly at the level of production of Hydrogen from via steam methane reforming from natural gas a lot of that production is also captive meaning. It's like. Let's say inside the refinery fence for fuel upgrading so but electrolytic hydrogen does exist. It's not it's not new and it's and it's not just a dream. So I'm not sure what else I could say that.

Schoenkin, Nathan (PHMSA)
OK thanks Mark does anybody else, want to add to that, if not, that is OK. OK, so with a hearing crickets, there, I will continue on a question from Joshua, Green hydrogen is hydrogen made from electricity that was created using a carbon free method. I.e. solar to give an example solar farm.

Solar farms create electricity doctor city is then used to create hydrogen using like trials as hope this helps so that was a comment so we will keep going.

OK next question from Joshua, has anyone looked into the fact that blended hydrogen and gas actually creates more CO2 emissions does anybody want to take that one.

Timothy
More UM carp carbon emissions certainly if you're looking to Green hydrogen or blue hydrogen, which is essentially decarbonized hydrogen from fossil almost exclusively natural gas through steam methane reforming didn't relatively low to very low carbon as part of the fuel source and so then you're looking at its transportation and so within the office of what was formally or like natural gas, but it is now the office of resources stain ability and in our division of methane mitigation technologies really our role is to try and minimize any leakage whether it be methane or hydrogen if we're transporting that along the pipeline to sort of remove the that that emissions factor there. So let me stop talking there, see what Mark has to say, and maybe I missed the mark.

Mark Richards (DOE) (Guest)
No you got it right, yeah, where you draw the box is important. So certainly if you draw it small enough you'll you can find no carbon solutions, but you know, and that's why the importance of life cycle analysis where the that comes in because that does go all the way across the production delivery chain to assess all of the elements that that could contribute to emissions and we've been doing these types of life cycle analysis for a long time and we have people at national labs? Who are very adept at these types of things and that's also why that's one of the early steps that we're taking within high blend is because unless you know the impacts and know the costs that therefore you do Technomic analysis do you know you're going down the right path? Are you taking a valid and valuable approach?

Timothy

Yeah, and I would just add one more thought there which made this question may come from the lines of transporting hydrogen as a as a gas. It has about a 3rd of the energy density of of methane when you transported pipe pipeline. So it would go. It would require more energy to to transport equivalent amounts of of energy essentially but again that's all predicated on us getting a better handle on leakage rates and Compressors pneumatic controllers etc. to again minimize or remove both see oh 2 emissions from engines as well as methane and hydrogen emissions from pipeline and other components.

Mark Richards (DOE) (Guest)
Yeah, agreed.

Schoenkin, Nathan (PHMSA)
Alright, thank you. Andy Miller or Matthew do you have anything you'd like to add? Feel free to say pass.

Miller, Andy
I'll pass thank you.

Schoenkin, Nathan (PHMSA)
OK from now on, I'm going to leave comments not questions within our document for the record and will continue on to the questions so the next question I have is from Michael Hill for Timothy Reinhardt. How is DOE going about determining the material compatibility of the existing natural gas pipeline infrastructure to handle hydrogen natural gas blends?

Timothy
So that's a very good question. In the short answer is with difficulty so it's very complicated thing to tackle but you have to look at as others have said both gentlemen from in the ERE and others, that you have to look across the board you have to look at the materials compatibility for new things materials. But you also have to look at what the actual in situ condition. Of those materials are and what has been flowing through them over the previous years decades, etc. And what impact that has on the materials and so it's both an assessment. It's a literature survey. It's looking at materials compatibility. There's lab work there for running different types of materials. Different types of dances rather through various materials, but ultimately, it's trying to come up with a database that tries to assess all of that and it's going to have to be broken down into either regional or either smaller levels to say you know this is our confidence level for transporting this you know blend wall of hydrogen in this particular section of pipeline. This is that we have a very initial effort in with Oak Ridge National Lab to work on this, but you know you're having to look at all facets of it across different regions. Different materials different natural gas chemistries to be able to assess all that so it's a multi year project. We're really just getting it off the ground and then we're going to have to turn in it, and others to help formalize this and make it part of the regulatory framework and Whatnot. So sorry for a convoluted answer to a question, but it's a very good one.

Schoenkin, Nathan (PHMSA)
Thank you and before we go along Sentho would you like to comment at all on that previous question about determining the composite material compatibility of existing pipelines.

White, Sentho (PHMSA)
Sure well that again is something that we're going to be discussing more during tomorrow's working group sessions. At least I think one of the working groups will be delving into that more because that is definitely a gap that that we have currently in terms of the blend and the percentage of blends in terms of compatibility with different types of pipe materials.

Schoenkin, Nathan (PHMSA)
Alright thanks, so much. OK, I'm continuing on from Matthew. You said the hydrogen can diffuse into the pipe materials and decrease its durability. Looked like cracking is the concern internal cracking or does it full or does it fold diffuse into the pipe and it is still creating external cracking? Who would like to kick this one off?

Mark Richards (DOE) (Guest)
I can I'm going to preface my answer with I am not a material scientist so there's many smarter people than me, but I believe the main concern is the internal cracking could because you're exposed to that hydrogen environment continuously and obviously things like depth of pressure cycle and things like that play a big role in fatigue crack growth. I'm not aware of anyone who's terribly concerned about corrects externally. I mean as a hydrogen mechanism. I could be wrong, but I think that's probably reasonably accurate.

Schoenkin, Nathan (PHMSA)
Alright Thanks Mark. Would Timothy or Matthew want to comment further.

Timothy
You know, I probably defer to Matthew here, but I would say that I believe mark is largely correct you know hydrogen diffuses. I think both along the surface and then more fully into the material body it. It diffuses so you know embrittlement is an issue across the board certainly interior cracking but you know, ultimately deterioration of the entire pipeline would certainly be a concern, but again, I'm not the huge expert here and input for that matter.

Schoenkin, Nathan (PHMSA)
Alright. Thanks.

Connolly, Matthew J. (Fed)
Yeah, I'll I'll agree there. You know, so the big issue why hydrogen is an issue is that it gets into everything right. So when it's in your internal pressure vessel or pipeline. Then it diffuses through the wall of that pipeline or pressure vessel. So it's in your material and if you have an existing flaw in the pipeline, which for miles of flaws. You can have pipeline you'll have tiny flaws and as you pressurize a few times a day and depressurize as you have demand and supply cycles. Then you get fatigue. On those pipelines and what we know from our tests is that if you have hydrogen near those flaws, then that that those boutiques cycles accelerate the growth of updos fatigue cracks so that's your main issue so.

Schoenkin, Nathan (PHMSA)
Alright thank you for that Matthew. Alright, we have time for a few more questions. One from

Matt apuna we have a question for Timothy. I observe from your slide deck that hydrogen gas is one of the areas DOE is involved in please provide some information on DOe efforts in this area. In addition, does deal, we measure quantify and harness the hydrogen straight gas emission/ seepage.

Timothy
So you know for fuel we wide hydrogen efforts and initiatives I'd defer to mark and the hydrogen fuel cell technology office and we are ready to actually have sort of oversight over the entire deal wide hydrogen effort clearly within our office. You know, we're looking at natural gas. Specific applications and things of that nature, but would defer to him for a further answer on that.

Mark Richards (DOE) (Guest)
I believe the question wasn't stated accurately, I believe the question was about hydrates. Not that I'm trying to not answer a question. I'm looking at the chat and seeing that it question was about hydrates.

Timothy
About methane hydrates.

Mark Richards (DOE) (Guest)
Yes.

Timothy
Oh, OK, so that is something we have looked at historically sort of a different tangent here. But we have historically had a methane hydrate program looking at both how methane 100 is created and how it migrates and potential production of it. We still have 2 ongoing large field tests in that area within the office bottle energy in carbon management were also looking at you know, potentially at some point in the future by hydrogen pretty naturally produced from hydrates systems, but we're getting a little bit into the weeds and I'm not sure I'm answering any ones question here.

Schoenkin, Nathan (PHMSA)
Understood but thank you. Thank you for providing through comments there. Alright next question from Rick Webber for Andy. Please talk more about the need for quantifying emissions related to proposed Methane rule how PHMSA efforts assist in that.

Miller, Andy
So thanks, I think there's a number of ways that PHMSA can really help here obviously you have a lot of expertise in pipeline operations on the equipment on the entire system and so those are important for us to understand in terms of emissions and of emissions mitigation approaches there's obviously I think a number of opportunities where we would welcome some collaboration input and engagement on how you see the outlook for pipelines. You know that's something that we really want to understand more is how our pipelines and operations changing are we looking at a significant level of Hydrogen methane mixtures here and what does that imply for emissions technologies and different practices and that can be as I mentioned in my presentation very closely tied to monitoring and evaluation for safety. So I think there's a lot of ways in which we

can work with Vincent and others to you know make this this process more effective in terms of costs more effective in terms of emission reductions.

Schoenkin, Nathan (PHMSA)
Alright thank you, Andy. We probably have time for 2 more questions, so these will be the last 2 for the panel. Fascinating work at NIST, the testing to assess impact of hydrogen on the cyclic strain stress. It's very interesting are you seeing a substantial reduction in strain life is that behavior observed in pipeline steels or much higher strength.
Connolly, Matthew J. (Fed)
So our strain life testing has been primarily focused on pressure vessel steels. We do see a reduction in Strain life so if you're looking at equivalent strain amplitude. We see about a factor of 10 reduction and strain life interesting since you ask about the higher strength. Our initial measurement, so I'll say we, we focused our what we call our baseline measurements on the 4130 steel so that's a steal with about 560 MPA Say your TS we have done tests on much higher strength steels up to actually 1050 MPA TS so that's a much higher strength steel and what we have seen so far is that the strain life in hydrogen for this much higher strength steel essentially overlaps. This baseline steal of a lower strength 4130 steel so the 4130 is well accepted in for usage in pressure vessels that the higher strength steel with the UPS of 1050 is not accepted for use with hydrogen, but we see the same strain life in hydrogen for both materials so this is something that we're pursuing further but it does not appear that this same sort of strength performance relationship that we see more or less in tensile, but not as often in fatigue where they're real damage where there will failures are happening in pipelines and pressure vessel. We don't see that sort of steam strength relationship and we're seeing it both in the fatigue crack growth rate and more recently, our tests in strain life are suggesting that we don't see that behavior as well so very promising.

Schoenkin, Nathan (PHMSA)
Alright, thank you, Matthew. I think the last question, we will probably answer here is the next one, isn't it true that Green hydrogen can be made from various renewable feedstocks and technologies. I.e. bio mass used in paralysis or gasification our engine. SMR and not just from solar slash wind electrolysis. The key being the feedstock needs to be renewable that is how California LCFS fuse it. Mark or Timothy or Andy do you want to take this one?

Mark Richards (DOE) (Guest)
I think the short answer is yes. The longer answer is the authority having jurisdiction I guess in terms of accepting something, as green hydrogen. They're the ones who are going to write the rules. And there may be some variation I guess and what gets in and out of the green box, depending on who 's writing the rules. But yeah, I mean, basically you're correct but with some variation I guess. Potential barriers.

Miller, Andy
Yeah, I'll just add to that that I think the analog at some point will be similar to EPA 's renewable fuel standard, which requires a life cycle evaluation and it's for CO2, but I think the same kind of thing would be appropriate here, but again as Mark said it's going to depend upon jurisdiction, EPA does not have any rules related to Green hydrogen, but I would expect that it would be similar. And requiring some lifecycle evaluation to determine the renewable content.

Mark Richards (DOE) (Guest)
Right.

Schoenkin, Nathan (PHMSA)
Alright, well. Thank you so much and Kandi. I'll turn it back to you.

Barakat, Kandilarya (PHMSA)
Yeah, thank you to all the panelists today for insightful and information on all the topics on hydrogen methane mitigation and others for your great efforts today and enjoy the rest of your afternoon back to you Bob.

Smith, Robert (PHMSA)
OK great well. Thank you, Kandi and panelists Timothy, Mark, Andy, and Matthew. We are now breaking for lunch and have 45 minutes since we're right on time here before returning we recommend either remain in the teams meeting but on mute or return and click on the meeting link again at just before 1:20 PM. Eastern so we will promptly begin at 1:20 PM eastern with the afternoon agenda and panel 3 international partners, right we are adjourned for lunch.

Smith, Robert (PHMSA)
Welcome back from lunch everyone PHMSAs hydrogen and emerging fuels R&D public meeting and forum for those of you who did not join this morning. I'm Robert Smith, senior research program manager for PHMSA Office of pipeline safety before we get started just a kind of quick reminder about some housekeeping items. Please remain on mute unless you are a presenter don't forget when it comes to questions. You are able to do that during the Q&A period used to team feature entitled show conversation that go ahead and add your question be sure to confirm if it's for the panel or for particular panelists and we'll get to as many of them as time permits. These proceedings while the transcript made available on the meeting website along with all the presentation files after the event. So let's go ahead, so I've panelists for panel 3 international partners. I heard you before, so I'll be ready to unmute when you're called upon. So let's go ahead and move on. It's now time for our 3rd panel so let me introduce Max Skiba, who is one of 2 operations supervisors for the engineering and research division within PHMSA's Office of Pipeline Safety. He's going to moderate panel 3 and the Q&A session following the panel. Max, let me go ahead and bring up the first presentation.

Kieba, Max (PHMSA)
Thanks Bob Hello, everyone panel 3 objectives to learn about measures and policy and research that our international partners are taking to address emerging fuels hydrogen and climate change challenges with pipelines. This panel has 2 presentations are first Co presenters are Simon Gant fluid dynamics team and Adam Bannister engineering materials team of the United Kingdom 's health and safety executive Simon and Adam will be sharing information on activities by the HSE and support of this panels objective Simon Adam please proceed.

Simon Gant
Thanks very much for the introduction and thanks for the invitation to attend this meeting. So yeah, I'm Simon Grant from the fluid dynamics team at HSE Science Division.

Adam Bannister
And I'm Adam Bannister from engineering materials at the same location.

Simon Gant
Alright Thanks next slide, please.

So here's a quick outline for our talk. I'll give a quick introduction to HSE talk about net zero targets some research challenges. We'll talk about recent ongoing projects and finish with some remaining knowledge gaps so next slide, please.

OK. So who's thee agency. It's the UK regulator for Health and safety and that includes regulation of all onshore and offshore pipelines. In terms of activities. We do the full range from research or the way to enforcement. The UK operates a risk-based goal setting regulatory regime, which is a little bit different. I think to the one in the US. That's based more around standards and codes. We've got around 2 and a half thousand total staff and a budget of around $300,000,000.00 and in terms of R&D. We do in house or in need to support agency policy and regulation. We support other government departments. We do joint industry projects where we have mutual interests between ATC and other industry companies, and we get involved in a consultancy as well. Thanks, slide, please.

OK so in November 2020, the UK government announced a 10-point plan to reach net zero carbon emissions by 2050. And that's focused around growth of low carbon hydrogen and CCUS and around regional hydrogen and situates clusters in the UK. And that's got ambitions for scaling up from neighborhood to hydrogen town trials by 2030 ambitions for hydrogen production and CCS and there's going to be a government policy decision on hydrogen overheating in 2025, that's actually been pushed to 2026 now. And the document that's linked to the bottom there. That talks about the other ambitions on net zero around offshore winds nuclear and so on. Next slide please.

So I think this is already been touched on before in in some of the DOE talks at this slide is looking at differences between hydrogen and natural gas or methane. The table on the left is focused on fluid and chemical properties and the one on the right on material properties and so on the left, I mean, the density is clear are smaller but hydrogen it's kind of much higher upper flammable limits the autoignition temperature. It's easier to ignite hydrogen one of the things so the bottom thing there. The equipment groups, so equipment that's rated for use in hydrogen atmospheres is different from that used in natural gas atmospheres.

Adam Bannister
The table on the right is a result of that some work we've done for 2 of our gas distribution network companies where we did an extensive literature review looking at pipeline steels and this is an attempt to summarize in one table. Some of the observed effects that we've found in the literature. For these types of steels again. Some of these have been touched on earlier what we generally find is that strength is largely unaffected by the presence of hydrogen int the green indicated areas. We have a couple of areas where we see some reduction, but not a major effect shown in in orange such as initiation toughness and the threshold for fatigue and also has

touched on earlier. We see some significant effects. So, elongation in terms of the ductility of the steel tearing resistance and fatigue crack growth rate, which we've heard mentioned before very much features where we have an active crack tip operating in the in the material under those test conditions and there's a few in in blue where these are high rate impact tests use as a as a proxy really, for predicting crack propagation in pipelines and the high strain rate associated with these don't really enable hydrogen to take effect as it's a diffusion limited strain rate. Next slide please. So just moving onto pipelines in particular. So a lot of the work we've been doing is on the transmission and distribution pilot lines. We also include in that above ground installations where we have some different steels and materials also operating which need to be assessed from the point of view of hydrogen performance. In terms of materials, we've heard a lot about embrittlement, which is particularly concerned in steals, undone fatigue as well, where we have cyclic loading conditions. These will need to be considered at the various stages of the design construction and operation of the pipeline in particular, maintenance and some of these potential degradation modes will bring with them. Additional requirements in terms of inspection both inspection frequency and inspection capability. In terms of risk assessments with hydrogen there will be a change in failure frequencies that there isn't sufficient operational data available yet to be able to say what those will be. We would also expect some leakage issues, from for example, joints those may behave differently in the presence of hydrogen than natural gas. And then because of the different characteristics of the gas will have different gas migration and from buried pilot lines and then how that gas may disperse accumulate and potentially ignite and that leads us to a different hazardous area classifications for the above ground installations in the in the pipeline network.

Simon Gant
And there's other challenges in operational procedures for pipeline purging venting inspection maintenance leak detection and repair. Some issues for equipment that needs to be looked at and training and regulation next slide, please.

Adam Bannister
So just a quick overview of the UK gas network. It's obviously a lot smaller than the US one, but this just gives a flavor of some of the features that are gas network involves so we have multiple companies operating across the UK. Some of them are shown on the map here. We divided our network up into first of the so-called national transmission system, which is the high pressure system, which is about 5000 miles typically X 62 X 80 grade steels. This then steps down to the local transmission system, which has is had a longer length, but smaller diameters typically X 52 and then we stepped down to the so-called distribution network below 7 bar and finally domestic installations and these latitude. Canning also involves a cast iron some legacy. A cast iron main exists in the UK network and that is gradually being replaced on a risk based approach, using polyethylene pipe. Next slide please.

So, just moving on to some of the projects with which he has been involved just to give a flavor of some of the approaches that have been taken in these various projects and the first one on this slide is high deploy. This was looking at a 20% hydrogen blend in natural gas to involved 3 stages first of all scientific analysis and some experimental work small scale experimental work as support for community trials. There's been 2 community trials, one has already been completed, which was at Keele University, which was a private gas network at a small

University in the UK, which was polyethylene and then now moved onto an actual live trial in a village in the Northeast of England, which is a small data network that serves 668 homes and that's running as of middle of this year. Just some images there showing the level of detail that we went into in this project with the partners so looking at forms and materials after soaking in hydrogen looking at explosion potential. The 4th image from the right shows some polyethylene pipe and Springs ready for soaking in gaseous hydrogen prior to testing and then on the right there. We have an image just showing some of our dispersion and release a practical testing and CFD modeling of that particular installation. And the age 21 projection on the bottom there, so that's looking at repurposing the existing natural gas distribution network for 100% hydrogen so in phase. One of that work, though, is a facility constructed on the HSE. Buxton site for doing leakage. Tests on recovered gas network assets so taste testing the one hydrogen and methane to look at the difference in leakage rates. Also, at DMV speed item there was some tests on looking at guest migration through soil dispersion accumulation ignition potential for an explosion tests and all of that was feeding into a quantified risk assessment and for some updates to operational procedures. I should say that's a 17,000,000 pound project, next slide, please.

OK, so change of material here, so H 100. This was a project that has largely completed the experimental part now. This was looking at 100% hydrogen in new gas distribution networks, so looking at polyethylene pipe again. The approach was small scale testing experiments and analysis to support the QRA and some images shown there just show how we've looked at a ducktail rupture slow crack growth and oxidation PE pipes and then on the right there are some dispersion tests looking at how hydrogen 100% hydrogen leaking from a uh a rupture in a polyethylene pipe would track through different ground conditions. A future grid down at the bottom there is a project that's just getting going. This is run by National Grid. And this is looking at the high pressure national gas transmission network. It's starting with 2% blend working up to 100% hydrogen. And this project is taking out existing assets of various ages and vintages from the current network to try and cover different types of grades of steels different manufacturing years and then extensive program is being planned here where basically rebuilding a small grid using these extracted assets at a site called Spadeadam in the northwest of England and then that will be run for up to a year where they'll be assessing the performance of the of the grid and also the effect on material properties at a later stage and that's just due to start testing in October 2022. Next slide please.

22 projects here quickly so hyper heat, that's a project looking at using 100% hydrogen in residential and commercial buildings and gas appliances. It's a 25,000,000 pound project. It's focused on issues downstream of the emergency control valve. There's reports available on things like Odorization gets quality some work. That's ongoing on metering and appliances. And there's 2 demonstration hydrogen homes. That being constructed, using hydrogen for heating and cooking and there's a picture there, of the energy minister outside them and then the hydrogen heating program. That's funded by the Government Department of Business energy and industrial strategy, so that's funding HSE to assess the evidence for safety of hydrogen feeding and looking at future safety regulation requirements and support to the hydrogen trials and next slide, please.

A project that's is currently due to start in in 2022. This is looking at this is a project based up in Scotland and this is looking at the end called the LTS future so the local transmission system and

this is project run by SGN who run the LTS in Scotland. We worked with SGN to carry out feasibility study looking at the repurposing of the LTS for both hydrogen and CO2 transmission. And that was completed last year and in that we identified with a potential existing but decommissioned line that they were interested in doing a trial on shown in the map here, so if you could see the 2 sort of blue flags in them at run from Edinburgh in land and that's the 20 mile decommissioned X 52 grade pilot line that this project is looking to use as a trial for hydrogen transportation it involves absolute live trial design. Material testing at a lab scale and then scaling up for the actual live trial on this particular line on the right there is just a sort of image that is produced from the land use planning analysis. That was also done in the initial based project, which looked at the change in land use planning zones that will be associated with moving from natural gas to 100% hydrogen. Next slide please.

OK just one quick slide on a CC West so there was a program of fairly significant research over about a decade from 2007 until the government withdrew support for that point, so there's a report that's available on a website that you can find out more information on research from that time since that period. There is now renewed interest in success through these regional hydrogen and CCS clusters. We were involved in some initial regulatory review of ongoing UK projects that are focused on using gas phase. CO2 pipelines onshore with compression at the coast and then dense phase offshore so there's interested in repurposing existing natural gas lines and the regulatory policy is currently under review for CO2 pipelines in a chat. Next slide please.

So just to close with some of the sort of remaining knowledge gaps. We've identified particularly materials aspect, so looking at the pipelines and associated infrastructure. One of the approaches that we used with the LTS project was looking at engineering critical assessments for pilot lines so looking at how the mechanical properties change and then how that would carry over in a structural integrity analysis to potentially alter the critical flaw size and the fatigue life. We've also looked briefly at some of the repair techniques, so for example, welding and hydrogen generally don't go together very well so there's potentially some area there, too. You know revisit some of the limitations of welding and safe hydrogen levels because that would clearly be an issue with Azure pipelines, and also hygiene tightness of repair clamps and sleeves that use polymer infills. As mentioned earlier on this presentation, I think was the beneficial potential effects of oxygen and one of the GNS gastric solution network companies interested in exploring that potential mitigation in more detail that we're also looking not just at the pilot lines, but also some of the materials in some of the assets such as steel Springs that we have involves a higher strength material potentially most susceptible to hydrogen embrittlement and we also have cast iron pipe lines in our network. So currently those are still within the limits of this type of work. With both hydrogen and CO2, there's an interest in in being able to model better crack growth. A good performance and in particular, with CO2 dense phase CO2, there is a concern with the fracture arrest capability and the capability of the current methods such as Patel 2 curve method to enable predictions of safe rest of fractures in with dense phase. CO2, so there are quite a few remaining gaps there in both hydrogen and CO2 areas next slide, please.

Simon Gant
And I think this is the final slide. Just a few last things so on safety of operational procedures. There's some outstanding knowledge gaps there. Other issues on safety of infrastructure and components issues to do with background leakage modeling and the effect of backfill use of

hydrogen and multi occupancy or high-rise buildings and remaining knowledge gaps in human factors issues so and that I this is it. Yeah, thank you.

Kieba, Max (PHMSA)
Alright thank you very much time Simon and Adam. Very informative presentation, especially like the color coded table on the effects on the research challenges and hydrogen property slide and for any non-engineers in the mix talking about scale, they mentioned transmission was 85 bar. That's roughly 1233 PSI and then distribution 7 bar roughly Hunter, 2, PS I so fairly equivalent to what we have in AUS so just want to let everyone know that. So thank you again for our second and final presenter is Peter Budgell, senior technical specialist with the research and innovation team for the Canada Energy regulator. Peter will be sharing information on activities by the CR in support of this panel subjective Peter please proceed.

Peter Budgell
Thank you very much Max and good afternoon, everybody. I appreciate the opportunity to speak to you all this afternoon. On the hydrogen initiatives that the CR is currently undertaking as Max mentioned my name is Peter Budgell, and I am the project manager overseeing the development of the CRS hydrogen strategy, next slide.

So before we get into hydrogen, I'll give you a short overview of the CRS role and our mandate and then we'll talk briefly about some emergency energies. Emerging energy sources in Canada. We'll start our discussion of on the government, Canada 's recently released hydrogen strategy for Canada and then we'll talk about how that strategy intersects with activities that are either underway or are currently plan for the CR and finally we'll finish up with some areas of interest in collaboration and, next slide.

The CR regulates over 73,000 kilometers of pipeline within Canada and essentially if pipeline crosses the provincial or international boundary, it's regulated by the CR. Pipelines that typically are completely within the borders of a single province or regulated by that provinces regulatory body. We have roughly 550 employees headquartered in Calgary, Alberta. And though we also have offices in Québec and British Columbia, so in broad overview we oversee how energy moves in Canada within Canada and to export markets, and we do this by overseeing the companies that operate on and gas pipelines and electrical power lines. We very specifically reviewed the applications for new projects and upgrades to current ones. We provide oversight of oil and gas activities on frontier lands and in the offshore that isn't otherwise regulated by that territorial body or provincial accord, we decide what can be transported in pipelines and how much companies are allowed to charge for their services. We approve import and export of natural gas and the export and export specifically of oil and finally we provide energy statistics and analysis and information to Canadians or whoever else would like to see it so, next slide.

It's a little bit emerging energy sources in Canada. There are several alternative and emerging fuels that currently form part of the mixing Canada, and all of these are likely to play a role in the future energy needs of Canadians and for export markets. We have a large landmass and with active forest and agricultural industries and of course. That means that Canada has access to large and diversified biomass resources and that can be used for energy production. Most of

biomass fire capacity is found in provinces with large forestry activities. So British Columbia, Ontario, Québec, Alberta and New Brunswick. So a good part of the country. Next.

We have biofuels and renewable natural gas and so given increasing demands for RNG. As an alternative fuel it's likely that feedstocks of these will be used directly in methane reforming rather than be converted to hydrogen, though, we may see more conversions to hydrogen as well in the future. When the council currently for about 4% of Canada 's electricity generation and both wind and solar energy deployments are growing hydroelectricity. Of course, is really the mainstay of County of Alberta, Canada. And then we have nuclear 14.6% of nationwide electricity comes from Canada 19 operating power reactors at 4:00 nuclear generating stations across Canada and of course. Canada is exploring potential to expand nuclear capacity through small modular reactors and that can provide non GHG emitting power in remote communities. A building on Canadian building on Canadian innovation in the sector. Now I'll spend the rest of my time here this afternoon talking about hydrogen and what we are currently doing at the CR to address the opportunities and challenges that it brings so, next slide.

Canada is currently one of the top 10 producers of hydrogen globally and we proved roughly 3,000,000 tons per year. Nearly all of this currently comes from steam methane reforming of natural gas and against this backdrop and after about 3 years of analysis and consultation last year that the Government of Canada released its hydrogen strategy for Canada. The strategy is billed as a call to action really to develop a competitive and sustainable hydrogen economy that that it's hope could make up, up to 30% of Canadian end use demand by 2050. The strategy itself contains 32 recommendations under 8 pillars and though there's implications across all of those pillars for the work of the CR will focus primarily on 3 that the CR is actively addressing right now, next slide.

So we'll start here with pillar for codes and standards CRS is participating in. Look at the CSA kind of Standard Association task force on hydrogen and renewable gas pipelines and the purpose of the task force is to review and update or requirements for gas pipelines to ensure that the pipelines containing that pipelines containing pure hydrogen blends or renewable natural gas plants are incorporated into the CSA standards at 6:62 pillar 5 is enabling policies and regulations and certainly we've heard lots of that this morning or in earlier talks. And, of course we are at early days of a lot of this hydrogen work and it'll be important to make sure that policies and regulations are updated or constructed to keep pace with the with the growing market. So we are currently reviewing right up to get us there and we are currently reviewing our regulatory and filing guidance to identify any gaps that may exist for the adoption of hydrogen. We are also liaising with other regulators in Canada and internationally to learn from their experience in regulating the addition of hydrogen to their energy mix. And there are credit provisions within the regulations that the CR operates under to handle either hydrogen for or other either pure hydrogen or other hydrogen vectors such as ammonia and where we're again, making sure that any gaps to accommodate that are being addressed as well.

And then if we switch over to pillar 6, so as I mentioned right part of the CR's mandate is to produce Energy Information Statistics and we do that through either one off projects or products like those the 3 bullets listed above, there, and these are we dive into a specific energy policies or energy market events and we try to give a an overview to Canadians and policy makers of how

those changes may impact the energy mix going forward. We also developed long term modeling for energy systems and our energy. Canada 's energy future publication, which is an annual publication incidentally the next edition of which is due out in in in just a few short weeks in early December. We try to make sure that future energy sources are taken into account when we when developed those long-term supply and demand models. And so in this year 's release we will talk a little bit about hydrogen and what role it may play in the future, and we are currently also working on some longer term supply and demand modeling additions. Looking deeper into the role of hydrogen currently and in the future in Canada, is hydrogen energy system and we are analyzing the potential for Canadian hydrogen exports so, next slide.

So finally we'll talk a little bit about areas of interest in collaboration, so the regulation of hydrogen or anything else for that matter requires a whole of government approach and as such, we work quite closely with other parts of the federal government. We work with Transport Canada or environment and climate change Canada Natural Resources, Canada or and many others, to make sure that we are all working with each other. To further their goal of having hydrogen become an important part of Canada 's energy mix in the future. There are official interdepartmental hydrogen working groups that we are a part of and we also participate in collaborations between federal departments and provincial departments provincial or territorial departments were, and working groups that are looking into Canada, Canada 's current hydrogen work and what that might mean in the future. So collaboration is key and we've seen that theme play out a little bit this morning and in the previous presentation and so in order to address all of the opportunities and challenges of adding hydrogen to the economy, we need to work together and so we've kind of split out our areas of interest and collaboration into a few main groups so from a regulatory standpoint, it's important that we not only develop consistent regulations code standards for the adoption of hydrogen within Canada but to talk to folks abroad in connected energy systems like in the US to make sure that there isn't a broader change when the regulation of hydrogen comes into play. As I mentioned earlier, we're working on standards development and technologies, so hydrogen blending and safety is an area of interest. For us at the hydrogen’s interaction with steel and other materials. We've heard that talked about a little bit this way, so far today. We do quite a bit of work talking or analyzing the market implications of carbon capture and storage and Utilization and certainly as I mentioned earlier nearly all of Canada 's current 3,000,000 tons of hydrogen comes from steam methane reforming of natural gas so that CCUS portion becomes vitally important for growth. And then we have some other areas of interest. Of course, risk assessment emergency response. We're looking into that currently and to make sure in the when we do see hydrogen in in pipelines regulated by the CER. We are ready with emergency measures or risk assessments so that the public is kept safe in that environment is kept safe. And then as I mentioned the environment long term environmental impacts and in particular, the potential impact on global warming and all of the work that we've committed to on that and so I think I'll switch to the next slide.

There I think that's pretty much all that I've had for you this afternoon. I really appreciate the time to give you an overview of what we've been doing and happy to entertain some questions. I'll preface any questions probably my way with the fact that I am not an engineer. I'm a lowly geologist. So, I do work with some wonderful engineers and to the extent that I can in the talk today. I'll answer and if not, we can certainly endeavor to get back to you on some of the questions. Thanks very much.

Kieba, Max (PHMSA)
Great thank you very much, Peter. It's good to see a lot of the standard center bodies being proactive. I know we have some of that here in the US as well. So, it's good to see everyone just starting to talk about these issues. It's really good. So let's now move to the Q&A session for the panel. Nathan, do we have any questions from the audience.

Schoenkin, Nathan (PHMSA)
Yes, we do so as with previous panels, I will read out the question and then I will go to the panel members and feel free to say pass and it will remain as a comment on there instead of a question so the first question is from Sam, is microbiologically influenced corrosion taken into account for risk/failure assessment. Let's move that one to HSE first.

Adam Bannister
Good question. Specifically, no it isn't what we've concentrated on is our failure modes that are likely to be enhanced by the presence of hydrogen so we've focused on the factors are affected by toughness and fatigue and those types of loading mode, so while mile MIC is still an issue. We didn't consider it to be significantly different to warrant a separate risk assessment with the presence of hydrogen in the pilot line.

Schoenkin, Nathan (PHMSA)
Thank you Adam. Any other comments.

Peter Budgell
I will pass on that one.

Schoenkin, Nathan (PHMSA)
OK, easy enough and Simon, I imagine you'll pass as well.

Simon Gant
Yep.

Schoenkin, Nathan (PHMSA)
Alright sounds good. On to the next question. Is above ground piping an issue for hydrogen pipelines due to coding versus wraps have studies been done on coding effects on hydrogen embrittlement. Let's start with CR or you're up on the picture already so let's go for that.

Adam Bannister
I can have a go at that one, the issue about above ground piping is more an issue of it's a different threat profile to the to the pipeline you know you have not got that you've got much more visibility of the external surface and you've not got such a risk of 3rd party damage. I think it's more to do with that Rosalind Coatings versus wraps. Have coatings been studied, yes, there's been some work on a metallic oxides as different hydrogen permeation, but they're quite expensive and there's a lot of pipeline to coat so generally, I think at the moment, the potential for a coating solution is quite remote. I think at the moment.

Schoenkin, Nathan (PHMSA)
Thanks and anything else from any of our panelists.

Simon Gant
Not for me.
Schoenkin, Nathan (PHMSA)
OK. Alright then, this one is definitely just for HSE on the age 21 project. What is the detection threshold for leakage? What is the precision of the analytic equipment being utilized?

Simon Gant
Yeah, so I can answer that one so in the test the primary interest was on the safety side, so the measurement equipment, the lower threshold for measurement was 100 CCS per minute and if it was leaking less than that, then it wasn't detected by the equipment that works for both hydrogen and for me thane leaks so in all, they tested. It was of the order 200 assets that were taken from the gas network of those I think they found that 40 will leak and they could get reliable. Some measurements of contrasting hydrogen to methane leak rates on about 20 of them. It was a fairly small sample in the end, but yeah, that was the shot at the analysis.

Schoenkin, Nathan (PHMSA)
OK thanks Simon, I'm off the next question here. I'm not sure I have the entire question down but I will raise it and if anybody would like to come on and answer, it is: why high string tests are not impacted much by hydrogen that seems counter intuitive.

Adam Bannister
OK, I'm happy to go with that one. The issue there is the relative movement of dislocations versus how quickly the hydrogen can diffuse now hydrant diffusion is enhanced at a notch or crack tip where the metal lattice is much more open, but still with the strain rates. You get in sharpie and drop weight tear tests. The hydrogen simply can't react quick enough to act at the notch tip. We found one I think one data set with presoaked Sharpie data for hydrogen on pipeline steels and it didn't show any effect and I think the general view is the slower the strain rate. The greater the effect you would see from hydrogen because of that diffusion relationship.

Schoenkin, Nathan (PHMSA)
Alright thanks, Adam. This next question we have here I understand you don't have any representatives from your embassies here today. So, I understand if you don't answer this one: are there trade implications when we're talking about collaboration on hydrogen? Feel free to respond how you would like or not.

Peter Budgell
Alright, I'll give a fairly standard political response to that one. I suppose of course, there's always the potential for trade implications, but it is very early days still in all this and as I mentioned during my talk, we're certainly in the collaboration phase and we're seeing quite a bit of collaboration and so the companies that are piloting projects, they're talking to other companies and they're talking to regulators and I think that's kind of where we're all at right now in in large part. And also why forums like this are very important so I'll leave it there.

Schoenkin, Nathan (PHMSA)
Thanks Peter. Max do you provide anything else before I bring it up.

Kieba, Max (PHMSA)
No, I'll just say for those that aren't aware when there are cross border lines, at least liquid lines, Department of State, then gets engaged on looking particularly at that cross border aspect so they'll look at a number of these aspects and you know what's being transported implications things like that, so as you can imagine once these things happen and number of agencies get involved. And also across the pond, depending on different components, we might have Department of Commerce sometimes gets involved too on some aspects, but again, with the intent being collaborative certainly and then also still looking at safety aspects and whatnot.

Schoenkin, Nathan (PHMSA)
I'll add Treasury to that as well when it comes to cases for technology collaboration.

Alright HSE do you want to comment on that or we could move on.

Simon Gant
Uh no just to say that I think meetings like this are great at bringing this sort of community together and sharing knowledge and finding out about what's going on internationally. So it's really great that you're organizing this.

Schoenkin, Nathan (PHMSA)
Great OK, my next question, and then we'll see how long that would take if we can have another one.

I'm aware of short pipeline segments transporting hydrogen do you believe there's adequate understanding to move on to longer pipelines previous nightly natural gas for transporting hydrogen? What is the possible timeline?

We can start with CR and then go on to HSE.

Peter Budgell
Sure, I guess I'll end up having to give an answer on this one again. I think we don't know I think we are all working towards that answer right now whether or not a long haul pipes that that had originally been used for natural gas or something else can handle hydrogen and I think I mean, as we've heard all morning and in the previous presentation, that's really where all of or a good chunk of the research is going is are these assets ready candidate can they handle all of this so I think we're getting there, but I don't think we know yet and as for timeline. Also, it's hard to say until we know the full scope of everything.

Schoenkin, Nathan (PHMSA)
Thanks Peter…HSE.

Simon Gant

The only thing I would add to that is that we have spoken to some of the industrial gas Companies like Air Products and BOC that operate hydrogen pipelines to see if the experience that they've got it can be translated into other areas like the district distribution pipeline network and there are quite significant differences in operating pressures and the type of assets. So, some of the stuff can go from one area to the other, but in other cases there's some research that's needed before you can go ahead and put in a hydrogen in your distribution network. Adam do you want to comment on that?

Adam Bannister
Yes, I would agree entirely on that. I think it's we're not there yet, but I'm particularly caused by some of these projects. Now, which are looking at really actually trialing in in existing assets or assets that have been removed and then reinstalled above ground to measure what's going on so you know using real materials aged materials. Not ideal new material so I'm quite encouraged by the way that it's now moving worldwide really.

Schoenkin, Nathan (PHMSA)
Thanks, Adam. I think we have time for one last question, and then we will turn it back to Max. What about internal coding impact with hydrogen.

Adam Bannister
If that means sort of existing coatings, so just flow coatings we've not come across any issue, there in terms of a negative effect. If it's about whether you can claim any benefit from those, the issue is where you have a Girth Weld. You have no coating so you always have exposed steel on the inside. So it's probably not something that we can really claim any benefit from that at the moment with the level of level of knowledge that we have. I don't know that answers the question, though, whether it's about to other coatings, but that would be my view.

Schoenkin, Nathan (PHMSA)
Thanks Adam. Anybody else want to provide a comment there or we can turn it back to Max to wrap up this panel.

Simon Gant
Nothing for me thanks.

Peter Budgell
Nothing from me.

Schoenkin, Nathan (PHMSA)
Alright I Max back to you.

Kieba, Max (PHMSA)
Right now, I would like to thank all the panelists for the great efforts today and over to you Bob.

Smith, Robert (PHMSA)
Well thanks for that Max and thanks for the panelists. Let's go ahead and proceed to the next panel so the panelists for panel 4 industry partners. Please be ready to unmute yourself when

called upon I just want to point out for Sean Miller, we weren't able to elevate you yet. So, your camera may not be working. But as you present Nathan should be able to change that, so if you wanted to use your camera at the Q&A part that would be fine. Alright, it's now time for a 4th panel so I'm pleased to introduce Massoud, the Hampton E Deputy Associate Administrator for policy and programs within PHMSA Office of Pipeline Safety. He's going to moderate panel 4 and the Q&A session following the panel Massoud, please proceed and I'll bring up the first presentation.

Tahamtani, Massoud (PHMSA)
Well, good afternoon, everybody thank you, Bob. We have already heard a number of very informative presentations from our public interest panel, from our government panel, and now from our friends from UK and from Canada. And there's been a lot of really good questions and answers back and forth. And we're very excited about the next panel, but I think it's time to give our industry friends the chance to talk to us about what's on their mind with respect to all the issues they've heard this morning and this afternoon. We have 4 panelists representing Aga PGA inga and APA. And our very first presenter who is on the screen is Sonal Patni. She is director of operation in Germany services with American Gas Association and with this, I'll turn it over to you now.

Patni, Sonal
Great thank you, and thank you for allowing AGA to be a part of this meaningful discussion. There was a lot of great conversation and I think a lot of commonality is you'll see as I walk through this presentation between what the industry wants as well as what the other stakeholders want, and I see that as definitely a positive whether it's agreeing on the fact that data should really drive where we focus our efforts or continuing to work towards reducing releases. I want to start by saying safety is and always will be our key focus. We want to make sure that as we transition to a clean future, we're making sure that we maintain the safety our customers trust and reliably deliver energy. Next slide please.

Today I'll start by providing a system overview of what emissions look like across local distribution companies and the declining rate of emissions from the natural gas sector. I'll then discuss the role that AGA and its members play in working to decarbonize natural gas sector. When discussing our role in a decarbonized future, there are 2 distinctions we need to make. The first is how we're reducing releases across our system and as you'll see shortly. Those efforts have already been underway. The second is how we displace what I'll refer to as conventional natural gas with emerging fuels such as hydrogen and RNG or renewable natural gas and discuss some key areas where R&D can further innovation and really help advance renewables and hydrogen blending. Next slide please.

For those of you who are not familiar with AGA. We represent over 200 local energy companies and these companies are responsible for 95% of the natural gas delivered across the United States. Next slide please.

I'm not going to go through all of these bullets, but from the statistics shown you can see that over the years emissions stemming from the natural gas systems continue to decline. Most notable is that second bullet, which shows an almost 70% decline as we've added 21,000,000

customers. I know what I heard this morning was we really need to use the data to identify where we need to focus these resources and based off of what we're seeing in these numbers and the reductions a lot of those reductions were stemming from energy efficiency as well as modernizing your pipeline system. A few weeks ago, President Biden also signed into law the infrastructure bill, which includes recommended strategies to increase energy efficiency for use in electric and as well as natural gas and hydrogen R&D for end use, including commercial and residential heating transportation and storage and also additional grant programs. Continuing to focus on energy efficiency and R&D have been critical in the in the reductions shown here and will continue to need that same amount of focus moving forward. Additionally, as you can see the use of natural gas also contributes to offsetting emissions from the power sector. So, as we begin framing the conversations of how we meet climate goals. We must consider how we leverage the existing natural gas infrastructure. Next slide please.

That being said, AGA and its members understand and are taking aggressive action to mitigate GHG emissions. AGA wanted to contribute and wanted to support its verbal commitment to carbon reductions with a document articulating our clear pledged to climate change mitigation. The purpose of this document is to articulate a clear statement from AGA about climate change and its positions related to key commitments and elements for possible climate policies, which you can find on our website. Additionally, based on what we've seen over the past year and what we saw in the previous slide, continuing to deliver energy reliably is significant and crucial continuing to invest in modernizing and leveraging the existing gas infrastructure allows for that. In fact, resilience and making sure critical infrastructure is in place was a key theme in the DOTs climate and resilience plan, which was released in October. Next slide please.

Although AGA members are engaging in understanding and seeking to incorporate both RNG and hydrogen. The industry has been focused on participating in in in initiatives aimed at reducing emissions. This includes participating in voluntary emissions reporting and programs with the EPA participating in industry studies to accurately measure emissions and refined emission factors and developing industry guidance to support proven steps strategies. But you'll see in the publications listed below such as reducing emissions from low downs, and AGA's white paper on eliminating hazardous leaks and minimizing releases. I believe there was a comment made earlier this morning about really identifying how different strategies, and tools can be used to minimize releases and that's really the point of one of the points at that publication and paper. Additionally you see that we're also developing a pending paper on what we had a lot of discussion about in the last panel was the impact of hydrogen on pipeline materials. This is really a literature review and looks at data from both US research as well as international research. Next slide please.

And there's a lot of discussion enthusiasm from policymakers and the communities that AJ members serve around the environment renewables. RNG and hydrogen and we see this excitement mirrored with our members are members take these actions and steps seriously. Pipeline Safety Trust made a comment earlier this morning at looking at how we best spend money when we really begin focusing on refining our data that really helps us identify where we focused these resources. As you can see here sorry I think I got a little ahead of myself. And as you can see here, this tracks where AGA members have already made some of those clean energy goals. Next slide please.

With RNG alone, 50 state bills have been introduced 27 of which have passed. 50 natural gas utilities have begun developing or implementing green tariffs in 20 gas utilities are engaging in the production of Orange and this is for the use in commercial and the residential sector, not for the transportation market. When we first started gathering this data, we only had 18 States and I want to note that just because we see a lot of activity, taking place across the country that doesn't always translate into new laws being passed. So I want to make sure that we don't overstate what the market looks like the market for RNG used in the building sector is still in its early stages, but with the right policy support and market demand. We expect this to grow significantly. Next slide please.

Gas utilities are also piloting hydrogen production technologies to evaluate the impacts on direct use gas equipment. Many gas utilities have begun to incorporate hydrogen into their emission reduction strategies while also educating policymakers regulators and customers on their plans for a hydrogen embedded guest system. AGA members support international research efforts to better understand the full scope of hydrogen impacts on the pipeline from blending low percentages into existing gas pipelines all the way to constructing 100% hydrogen microgrids. Next slide please.

So now that I've presented on what AGA and our members support. I want to focus on the main issues. We're here to discuss how do we address emerging fuels and use reach research to further that innovation. Well, as I already alluded to we need to focus on innovation and R&D. This includes all aspects from advancing leak detection technologies to identify a renewable blends to helping identify those larger releases. AGA and the natural gas industry have always worked and will continue to work collaboratively with researchers and academia to advance innovation. I'll identify a few of those areas in the next couple of slides.

Next is policy priority as I mentioned before and the market for our energy use in the building sector is in its early stages, but with the right policy support and market dependent demand, we expect that to grow. This also ensures pathways for this also includes ensuring pathways for R&D and hydrogen and all energy sectors, not just for the residential use. Also as we have learned technologies need to be flexible. One technology solution may not be optimal for all environmental conditions or systems and prescriptive regulations may further hinder innovation. Lastly, continuing to openly share new data finding and processes that can be incorporated by operators or help refine where to focus decarbonization efforts are critical. This also includes educating policymakers and our customers. Our customers trust our team members to safely deliver energy and we don't intend for that to change based on if we're transporting natural gas for Noble natural gas or hydrogen. Next slide please.

Building off my last point on using PHMSA data, we can see that an increase in leak that there's an increase in leak from certain vintage pipelines and the impact of excavation damage on the environment, leveraging data can help us identify areas to further. R&D efforts in this case, focusing on R&D as it relates to the rehabilitation of vintage pipelines or helps prevent excavation damage. Next slide please.

So based on what we know and what challenges are ahead of us, where do we believe innovation

is needed? Well, first when we're talking about reducing releases. We want to focus on ensuring we accurately capture the emissions from pipelines and pipeline facilities up-to-date emission factors are needed to identify where operators should really focus strategies to reduce emissions. Additionally, a better understanding of the different practices and technologies to detect plumes reviewed by past inventories. And the 2020 well or assessment that was previously mentioned will really help us focus our resources and efforts in a meaningful way. This also includes identifying larger leaks and focusing on getting significant reductions from remediating those leaks with respect to displacing conventional fossil fuels. AGA has identified the following topics that you see listed some of which then to in the other presenters had mentioned so continuing to focus on integrity and our infrastructure, whether it be for pipelines fittings underground storage compression and LNG are all really critical pieces. Additionally, continuing to focus and increase the efficiency of technologies whether we're discussing the efficiencies of landfill digesters having on site gas quality monitoring. Instead of sending us samples to a lab or even built-in efficiencies for your power to gas up electrolyzers. This is a great place for us to focus our R&D efforts. Next is leak detection as we look at blending whether it's renewable natural gas or hydrogen. It's really important that we make sure that the equipment that's used for leak detection continues to function optimally. Also, there needs to continue to be work done with operators to understand their specific gas quality requirements. This is not only critical for making sure that equipment functions correctly, but mostly for safety. There's also been a lot of discussions and will continue to be discussions around ensuring odor fade does not occur. And also as we heard mentioned earlier, the impact to inline inspection technologies based on hydrogen and the functioning of those tools. As well as potentially looking at the extraction of hydrogen. Next slide please.

We're committed to collaborating with local policymakers, federal regulators, the Biden administration, as well as stakeholders to reduce greenhouse gas emissions through Smart Innovation. New and modernized infrastructure in advancing technologies AGA looks forward to working collaboratively with PHMSA and the other stakeholders to advance these efforts thank you.

Tahamtani, Massoud (PHMSA)
Thank you Sir. I appreciate your comments. Our next speaker is Steve Squibb, who is the director of gas operation at the city utilities of Springfield in Missouri and he's representing the American Public Gas Association, Steve it's yours.

Steve Squibb
OK. Thank you Massoud and good afternoon, everybody. I appreciate the invitation to participate today. It’s been a great forum so far. You'll probably hear a lot of the same topics that have already been mentioned but I think that reinforces that we're all kind of on the same page here where we need to go. Again, as Massoud said, my name is Steve Squibb, director of gas operations at city utilities of Springfield, Missouri. So utilities is a member of the American Public Gas Association, who will be representing today and also be representing the APG, a Research Foundation, which is a separate organization that I'll talk a little more about in a couple slides, next slide, please.

So a little bit about a PGA. PGA is the only not for profit Trade Organization representing

America in publicly owned natural gas local distribution companies. So, we have over 700 member utilities in 38 states together, we serve approximately 5,000,000 gas customers. We have approximately 21,000 employees and our members operate about 120,000 miles of gas main something a little unique I think is the wide size range of our member utilities from the very smallest that may have 38 gas meters to the the largest of over half 1,000,000 gas meters so. So our typical member will still be small but I think collectively we operate and represent many, many communities across the country of which we are owned by those communities and we represent them and our goal, of course, is to number one provides safe natural gas to our communities that's reliable and also cost affordable so next slide, please.

APG's mission is to be an advocate for publicly owned natural gas distribution systems and educate and communicate. APG members to promote safety awareness performance and competitiveness, so on the graphic of the natural gas value chain. There you can see we mainly focus on the very end of the value chain. The distribution systems that are running amongst our communities. Some of our members also do have you know some transmission pipelines and transmission facilities, but typically we're focused on the distribution systems. Next slide, please.

And APG and its members are focused on environmental stewardship. APG created an environmental task force to help its members with the initiative towards environmental stewardship. The task force created a APG commitment to environmental stewardship and I've got a couple bullet points there taken out of that commitment that do relate to emerging fuels so the first one, is evaluating and incorporating low or no carbon energy sources such as renewable natural gas and hydrogen in supply portfolios when available, and Infeasible and the next one is investing in research development and deployment at the mission mitigation natural gas delivery efficient end use technologies and the use of new fuels when effective so we are focused on environmental stewardship. They want to be a part of this effort and continue to utilize our very valuable infrastructure to provide the energy needs of the country going forward next slide, please.

Education at APG is really focused on educating our members with the industry trends. We do that through conferences meetings and webinars. APG members often collaborate and share best practices for continual improvement to improve the safety and performance of our gas systems. There's a couple opportunities I think that APG members have to utilize emerging fuels. The first one, the first bullet point, you know several APG members operate in rural areas, where R&D may be available from farming or agricultural operations. The next one APG members are municipally owned, and I think have a great opportunity to partner with the municipal wastewater and landfill systems in their communities to utilize renewable natural gas. Next slide.

I learned about the APG Research Foundation again, this is a separate organization from APG, but is really focused on pooling the funds from our members, so the Research Foundation has 155 utility members again we pool our funds together and allocate those funds towards research initiatives in the industry. The individual members may not have the staffing or resources available to do their ow. R&D projects so this is an efficient way to pull that money together and efficiently contribute to the industries R&D efforts you can see on those next bullet points that the Research Foundation contributes $500,000.00 annually to the operations technology development organization, which is really focused on our gas delivery and distribution systems

and improving the safety and efficiency of those systems, and I think you'll be hearing about the organization in a future panel today. We also contribute $350,000.00 annually to the Utilization Technology Development Organization and that is really focused on the end use. Appliances and equipment that use natural gas and making those more efficient and safer so I think that's an important piece of the puzzle when we're talking about emerging fuels. We can't forget about that part of the equation. Just some examples of R&D projects related to emerging fuels and hydrogen that the first one hydrogen blending impact on plastic pipes. Of course, distribution systems are primarily installing plastic pipes. Today, old vintage plastic pipes from the 60s and 70s to the current residence we use today. So, what is the impact of hydrogen on those next is the effect of hydrogen blended natural gas on gas meters and regulators? And the next one impact of renewable natural gas on end use applications and appliances next slide, please.

And here's a list of just some emerging fuels R&D gaps that I think a lot of gas operators still have you know several questions on. What's the impact of emerging fuels and hydrogen on the gas systems? But the first one, is a lot of these have already mentioned before, but just to go through this again: Development of safety protocols regarding the large explosive range of hydrogen in our operators or our technicians in the field, you know they know the explosive range of natural gas units. Approximately 4 and a half percent to 15% gas in error when we start introducing hydrogen and other fuels. How does that change? What do they need to know in the field to keep our communities safe? I think I saw on the previous panel, the hydrogen explosive range is much larger, it's 4% to 75%. So how do we safely operate our systems with that in our gas now. Next one, impact on accuracy of gas leak detection equipment is related to the first one. Our technicians use gasoline equipment everyday surveying our systems for leaks. Responding to emergencies and in gas leak calls and they rely on that equipment to tell them whereas the gas what's the concentration of gas? Are we in a hazardous environment or are we not, and we need to ensure that equipment is accurate when we have these new blends of natural gas and do we need to be looking at new technology to account for hydrogen and other fuels? Next, as sort of been mentioned before, compatibility with natural gas odorants. That's our first line of defense to identify and report gas leaks and what is the impact on emerging fuels on deodorant next development of instrumentation to monitor RNG and hydrogen we monitor continuously our gas quality with chromatographs. We know what the composition of that gas is do we need additional instrumentation to monitor real time the components of RNG in hydrogen. Impacts on various infrastructure materials has been mentioned a lot today. So, I won't spend a lot of time on that. But steel plastics cast iron and the elastomers don't forget about that. The rubber materials in our gas equipment such as pressure regulators and gas meters. And the next one impact on gas system capacity due to the lower energy content of RNG be with the concept that in order in deliver the same energy to our customers. With a lower energy content potentially are we going to have to flow more gas to get that same energy to our customers and don't forget about the end use appliances. How are they going to react to lower energy content other potential safety issues with the appliances with lower energy content gas? And finally looking at an integrated systems approach of all this combined RNG with hydrogen with natural gas does that change the impacts to our guest system and how we how we operate safely and also want to mention just the consistency of our natural gas. It's fairly consistent today. The composition is slow to change with RNG and hydrogen is that composition going to be changing rapidly day to day hour by hour. Are we going to need to know the composition of our gas throughout our guest system to properly and safely operate our system? So that is the next slide, please.

We appreciate your time today and we will take questions at the Q&A session. Thank you.

Tahamtani, Massoud (PHMSA)
Thank you, Steve. I appreciate your presentation, and our next speaker will be presenting the Interstate natural gas sociation of America is Mister Shawn Miller, the vice president of engineering and construction with BHEGT&S and welcome Shawn the floor is yours.

Miller, Shawn (BHE GT&S)
I just want to say thank you for the invitation to present today. I think it's a very valuable forum. I think what you'll hear in my presentation won't be wildly different than anything that's been discussed so far, but looking forward to it. Again, I'm Shawn Miller, VP of engineering construction at BHEGT&S. I've got about 20 years' experience in natural gas transmission industry various engineering and pipeline safety roles. I'll focus on inline inspection corrosion prevention damage prevention regulatory compliance storage and major construction. I can be achieved as an in game member Interstate natural Gas Association of America, who will be representing today, next slide, please.

So the Interstate natural Gas Association of America or INGA, is a trade Association that represents the interests of Interstate natural gas pipeline operators. In this 26 member companies are dedicated to ensuring the safe and reliable delivery of natural gas and also work together to achieve industry leading performance and safety operations and Environmental Protection. Interstate natural gas pipelines are the highways of natural gas transportation network serving as an indispensable link between the natural gas supply and end users like residential and commercial consumers power plants manufacturing and industrial consumers. Next slide please.

Operate almost 200,000 miles of transmission pipeline. On the map you see in front of you here is it's is depiction of that across North America. One point of clarity what you see on there labeled is Dominion Energy Transmission and Dominion Energy. Carolina gas transmission are the footprint of what is now BHEGT&S regarding our pipeline network. Next slide please.

So a little bit about our company, I've got a map here included that again shows that the pipeline footprint we operate about 5500 miles of gas transmission, which interconnects 756 BCF natural gas storage. We also operate a fleet of LNG facilities codepoint in Maryland and also Towanda in Pennsylvania and trust villain, Alabama and the jax LNG facility in Florida. And before I move on to the rest of the presentation, just so you know I want to point out there's no secret, this smart investments in pipeline safety research and development over the years have greatly contributed to making US pipeline system safer and more reliable. England and it's members work with the INGA foundational key research priorities to help advance safely and regularly looks forward to PHMSA R&D forums to learn what friends with the best and brightest minds across the government and private sector are working on in order to reach our shared goal of zero incidents and we're excited to be presenting at this forums purpose of emerging fuels and energy transition, and we think in game members will play a pivotal role in this area. Next slide please.

In 2011 INGA adopted a series of safety principles and commitments called the integrity management continuous improvement program for IMC, focusing on working together as an

industry to enhance safety. Several months ago, Angus membership came together and decided that with recent strides and energy transition now is the time to update this program to focus on prioritizing safety as we prepare for zero carbon future, which aligns with focus on this forum on emerging fuels and energy transition. With that in mind, anger has developed with critical input of key stakeholders, including PHMSA are the pipeline safety trust and the Environmental Defense Fund. 5 guiding principles and 8. Key initiatives for this effort, which we call MCI 2.0. I'll start with our guiding principles first our goal is zero instance or committed to a strong safety culture and we can't get to number one without that, it's not just about the stats, it's about fostering that culture within organizations. 3 will be relentless in our pursuit of improving by learning. The 4th or committed to implementing continuously improving pipeline safety management systems. And lastly will regularly engage our stakeholders, much like we're doing today. The 8 key initiatives are listed on this slide. I won't go through them all, but I would like to highlight 3. In this case hydrogen renewable natural gas and the reduction of methane emissions due to integrity and maintenance activities. Next slide please.

As many of you already know RNG represents tremendous potential and Decarbonizing. The gas transmission network by replacing natural gas with methane from agriculture landfills wastewater treatment facilities and others. With demand for RNG growing, England and its members decided that focusing on sharing information on the safe transportation and storage of RNG is critical to the industry and key stakeholders. Initiative will draw upon England members decades of experience safely transporting RNG so we can work together to safely deliver larger quantities of it. The objective is providing the members with the technical guidance document that describes best practices for transporting and storing RNG. With respect to potential research needs, we see the need to understand integrity impacts of RNG constituents and pipelines underground storage and the feeds to LNG export and peak shaving facilities. As we're beginning to see requests to bring RNG into our own system, our focus on evaluating operational and asset impacts of various constituents areas of concern range from the potential masking of odorant by ammonia to potential detrimental impacts of products of combustion when RNG is burned as fuel. Next slide please.

As you are also aware, didn't represents tremendous potential in decarbonizing the gas transmission network with a similar desire by many for hydrogen to be increasingly included within a natural gas value chain. Inga felt it was a good time to provide us members with a compendium of information to help foster ideas to move the commodity safely. The objective is the key initiative is to providing members with current information, summarizing technical challenges, and how to mitigate them to enable the safe transportation and storage of hydrogen. This will include managing the interchangeability of gas containing hydrogen among other things. With respect to potential research needs, we see the need to understand safe levels of hydrogen blends in pipelines underground storage and feed LNG export and keep shaving facilities. And I think you know, we heard in the last panel, certainly focusing this here at GTS trying to understand the impacts of our existing system and can it be made to handle these products safely both hydrator hydrogen into hydrogen blends. Next slide please.

So even as we decarbonize the network, we have to keep focus on controlling emissions from Blowdowns. When we conduct integrity related work and other maintenance. England and its members recognized that emissions can be reduced in many instances, but doing so must not

degrade safety. We are working together to produce a best practice white paper, focusing on various strategies to reduce emissions from the Interstate natural gas pipeline network. We've been introduced to a couple of practices that we think are productive in this manner. A couple examples: we utilize portable compression to move gas from one section of a pipeline to another ahead of outages for replacement due to class location changes or perform pressure tests as an assessment for stress corrosion cracking. And on a related note, we see an opportunity in the regulatory environment to in regard to changes that may allow for alternatives to replacement when classifications do which classification changes do occur. On the integrity side we utilize a similar technology of the on a smaller scale during pigging operations to minimize the volume of gas blown down to atmosphere during all our launching and receiving operations. So with respect to potential research needs, we see the needed defined technology solutions for capturing and reusing gas collected during integrity and maintenance work. So I briefly described to you 3 of the 8 initiatives now MCI 2.0, and all I can say is, we don't have that I'm here today to go through all but we're excited to work on the other 5. We see them all, adding value solutions to the problems that we've been discussing here today.

So, I'll close by thanking PHMSA again for the opportunity to address you today and for their work on safely transporting emerging fuels. I look forward to answering your questions.

Tahamtani, Massoud (PHMSA)
Hey, thank you, Shawn. And our last speaker representing the American Petroleum Institute is Dave Murk, who's the director of pipelines midstream with API.

David W. Murk
Thanks, Massoud. I appreciate it and let me first thank PHMSA for the opportunity to participate today in this R&D forum and more importantly, your continued engagement with stakeholders on R&D priorities. You know the recent advisory committee meeting where you had the R&D as a policy update and discussion just again shows that the commitment that you all have and the priority placing on our end in that engagement and collaboration with key stakeholders, including the industry so really, really appreciate that. As Massoud said. I'm Dave Murk. I'm the director of pipelines for API in the Midstream segment and for those of you who aren't familiar with API, API represents all segments of the Americas natural gas and oil industry and through that we support more than 11,000,000 jobs and are nearly 600 members. We produce process and distribute the majority of the nation 's energy. For the purposes of my presentation based on the fact that I'm in the Midstream segment, I'm going to talk primarily about some transportation pipeline with respect to low carbon energy infrastructure hydrogen, etc. But just keep in mind as a trade as we're looking in the Midstream space and looking at pipelines and the use of emerging fuels were also kind of cross pollinating and working with our other segments to make sure that as we're advancing infrastructure. We're looking at it from a system perspective and so I will touch on this a little bit from our production side and some of the standard debt that we're looking at updating based on some of those needs as well and our upstream segment. You know you're including some traditional areas of safety, but we're looking at really at cleaner energy for the future, and clearly based on the discussion today and discussions on this panel as trades, we're all looking at hydrogen renewable natural gas and other low carbon energy and the implications of it, next slide.

Although as an industry, we recognize the benefits from hydrogen and low carbon. As you've heard throughout the morning and this afternoon, there's clearly a lot of risks associated with the development or re purpose of existing infrastructure to support any growth that that we might see in this area and with emerging fuels and with hydrogen and when I'm talking infrastructure. We're talking about pipelines as well as associated facilities underground storage, etc. And there's clearly some gaps that we need to address and as Peter said in the last panel, we really don't know there's a lot of uncertainty around the safety of pipelines and so from a trade perspective as we're working with our member companies to advance for those who want to advance hydrogen and emerging fuels and the development of infrastructure. We looked at really some key drivers risk drivers and clearly safety is a priority for our industry continues to be a priority as we strive towards zero incidents. But safety in an area of emerging fuels that we know some about but there's clearly more that we need to understand and R&D is going to be a critical aspect of that. But there's other areas operators are looking at potentially developing infrastructure, there's sighting and permitting there's environmental requirements. There's oversight at the state and federal level. But for the purposes of the discussion in my presentation. Today I'm going to really focus in on the on the safety aspects so, next slide.

So as you know again a lot of what on this slide you've heard throughout the morning and you know as we were looking at this safety risks and the risk drivers we really focused and on the safety side. We are focusing on the materials design and systems, the operations and maintenance, and the integrity management. And then workforce training as really the 4 key areas of safety and I think it's important that we now lose track as we're talking through a lot of the technical aspects of what's needed what? What's potentially needed? What do we need to be looking at it from a research and development standpoint to develop or repurpose existing infrastructure. I think it's important to look at all aspects of this what's the workforce training look like and Bill Carrom hit on that a little bit the social Sciences piece working with the public. What does that look like? What does that public education need to look like, and I think Peter or somebody earlier also mentioned emergency responders and training and preparing emergency responders for a type of fuel that they're not, in most cases, probably not familiar with so you know, we're focused on the R&D and the safety side and working with our members, but there's also a lot of these other areas that we don't want to make sure we don't lose focus on from a training and from an education standpoint. Next slide.

So as a Trade Organization, API has been a standard setting organization for over 100 years. So when we're looking at R&D and we're looking at more emerging fuels in that low carbon energy infrastructure and the implications on safety. We're ultimately looking at what does that mean from a standard standpoint as well what standards do we have we have over 700 standards that again across all 3 segments of our industry. But when it comes to hydrogen development, renewable natural gas or any low carbon energy infrastructure in the role that plays. What is it from a standard standpoint that we might need to update and I'll talk about some of those key standards that we're already starting to look at or are there other standards that need to be developed to provide additional guidance and practices to our industry to support those key those 4 key areas that I mentioned earlier, including operations and maintenance integrity, material design, and construction. So as we're again an organization that is a standard setting organization that's a big aspect of what we're looking at as we're developing priorities from a research and

development standpoint, ultimately that helps inform our standards, which I'll talk about here shortly so, next slide.

So research and development and you know clearly we've heard from a lot of the various agencies this morning on their R&D and I know I'm missing EPA on this list and there's others. But there's a lot of agencies that are doing research and development, but the industry is doing a lot of R&D as well, and you'll hear from Cliff Johnson from PRCI and others on the next panel you know, we work closely with PRCINGTI and other Research and development bodies but individual companies are also doing a lot of R&D as well, but from us again going back to the standards and the changes that we need to make to support the industry and the development of infrastructure or repurpose infrastructure. You know, staying connected closely with the various bodies that are doing R&D is absolutely critical for API and again that a lot of the R&D that is done is clearly helping inform on the standards and the leading practices that that we're developing. So next slide.

So from a standards standpoint, you know, there's some of our standards that are kind of easy upfront clear standards that we knew were going to have to take a look at and a lot of the technical reasons for that were have already been discussed throughout the morning and early afternoon from some of the folks diving into a lot more of the technical side of things, but API lemon 04 welding and pipelines and related facilities that's one that is widely used throughout the world into one of our most utilized the standards, but you know, there's work to look at hydrogen pipelines in the infrastructure and what does that mean from a welding standpoint, so we're looking at that and again we do a lot of outreach as a standard body. We do a lot of outreach and work in close collaboration with other standards bodies such as asthma, and Amp formally nace and the work that in the standards that they have and what are the implications and the connections that are standards have in the work we're doing with some of their standards and then line pipe 5 L. In the manufacturing of line pipe and that again. That's another standard, that is widely utilized as important from a material design and construction standpoint and so we'll be looking at that and that works already started within both of these respective committees to take a look at the implications around line pipe manufacturing as well as welding so, next slide.

And then as I mentioned earlier, we API represent all 3 segments of the industry. We look at even though I'm focused more as the director of pipelines and Midstream focused more on the transportation aspects of Pipeline Safety and this particular issue. We're working closely with our upstream and downstream segments and on the upstream side also looking at where hydrogen effects equipment from the production standpoint from the materials standpoint and so there's again a review ongoing of standards both in the Midstream and upstream side in particular again looking at it more holistically and from a systems perspective. Next slide.

So just to close this again I think for a lot of us clearly and just hearing the discussion today hydrogen and moving into what API we're calling low carbon energy in the infrastructure needs and development. We actually established a standalone subcommittee, which is at the same level as our pipeline subcommittee and natural gas infrastructure subcommittee handling liquid and natural gas policy and standards issues. We've elevated this to that level, which reports directly to our executives on the Midstream Committee and they're going to be looking at, I'll show you the kind of the laundry list of issues they're going to be tackling as a group. But right below you

can see at the at a higher level. Some of the things that again a broad brush perspective will be looking at in R&D is one key area. And they will have again a Direct Line to our Midstream Committee, but our pipeline subcommittee and we have a hydrogen task force that we've had in place now for about a year under our climate committee. We have a climate committee, which was created as we rolled out our climate action framework early last year or 2 years ago, now. So that group is also looking at it from a broader API perspective and then the last slide. These are the actions of that subcommittee again they're looking at it and if you go back…you don't need to come back, but that first slide of risk drivers in the areas that we're focusing in on you know, I've talked a lot about the safety components. But the uncertainty around the ability to get infrastructure built right there's still a lot of unknowns around that aspect of infrastructure. I know as Sonel mentioned the infrastructure bill has grant money and there's a big focus on hydrogen hubs and infrastructure development, but again still a lot of unknowns so as a group not only is this subcommittee going to be looking at safety, they're going to be looking at permitting the economics of trying to develop this type of infrastructure. What are the hurdles collectively across the board at the federal and state level that would impede operators from and developing infrastructure, but as you can see highlighted the in one of the most important pieces for us as we're moving forward is continuing to look at the R&D needs at what are the technical concerns and challenges that we face and we heard we've heard a lot of them today and those are those are the types. This is the type of forum for us as we're looking at what standards need to be updated it. It's that collaboration and truly understanding through these types of forums and what the needs are and what work needs to be done to help us as well. So as I mentioned we have a close collaboration with PRCI we're looking to be a part of their emerging fuels Institute, which I think Cliff's going to probably touch on here on the next panel and again, having that close collaboration with research and Development bodies is critical as it helps inform the changes we need to be making from a standards perspective.

So I think that's my last slide again. I just want to thank PHMSA for holding this type of forum. I would continue to encourage PHMSA to continue to, maybe on a more frequent basis outside of the forums, to engage with stakeholders in the industry on R&D. Be across the board and you know beyond emerging fuels into a traditional R&D areas as well. So, I just want to thank you. Massoud and and PHMSA for the opportunity to present but more importantly to have these forums. I think the next couple of days are going to be really important through the workgroups to truly flesh out what the priorities are in this space so thank you.

Tahamtani, Massoud (PHMSA)
OK. Thank you David I appreciate it,

David W. Murk
Thank you.

Tahamtani, Massoud (PHMSA)
With that I will turn it over to Nathan to see if we have any questions from our audience.

Schoenkin, Nathan (PHMSA)
Thanks Massoud so just a reminder if you have a question, please put it in the text box, that way what we will do this is I will read out the question and then I'll pass it over to the appropriate

panel member or to all the panel members to respond if a panel member does not feel like responding please just say pass and we can move along. Alright so this first one, is a long one so please bear with me. It's for Steve Squibb. It's great to hear the acknowledgement that we need to address variable gas quality and new analyzer needs to be ready for R&D and H2 on the measurement and accounting side. We need more than just having the technology to analyze and report content before we roll that technology out. We need to address in our standards and our contract/tariffs are communications networks and software systems. We need the industry standards to be on the on top of Green Energy, not bringing up the rear who is championing the standards work, they'll need to be done and where will those resources come from?

Steve Squibb
Yeah, thanks for the question very good question so that's a good point that it's great to develop technology and instruments to measure gas quality. But what is the standard? What is the new standard we're trying to meet and to be honest, I think from the gas distribution side of the industry we rely a lot on our pipeline suppliers and the transmission side for the gas quality specs and their tariffs currently so definitely needs to be a focus. I don't have a good answer who should champion that I know David just talked a lot about standards with API, but I'll open it to the other panel members for some input.

Patni, Sonal
Hey this is uh Sonal Patni. I want to address that question and make sure that I actually understand the question so I think there's standards for how you're doing the testing and where that testing is being done and the frequency and gas quality is something different right guest quality is essentially something that's established based on how the original system was set up and I can just speak to California because that's where I came from, but you know gas quality standards unilaterally applying a gas quality standard nationwide probably is not going to be effective because even when you look at different systems within a state or even operators that operate in different states. There's different gas qualities right and if you're changing those levels or the constituents that you allow you're really affecting those systems and you're really affecting safety and so when I think of gas quality standard and who should champion that my personal belief is you really need to make sure that you're ensuring for that flexibility and I don't really think you can have a unilateral standard that's my personal opinion. I'm sure there's other operators that feel differently or agree with me that are also on the line. But you know talking about gas quality, it's really system specific and it's really how each piece of equipment that's on that system has been calibrated so it's a little different than just doing a practice differently. Because you would have to physically go touch each piece of equipment and that's like going in everybody's house going in your larger industrial customers. Millions of dollars to change those turbine blades or equipment or whatever it is so I just want to put put that into perspective. So I don't know if I really answered your question. But I don't think that there can be like one person that champions. I don't know if others on the panel have anything else they want to chime in on.

Schoenkin, Nathan (PHMSA)
Thanks. Shawn or Dave?

Miller, Shawn (BHE GT&S)
Yeah, this is Shawn. Just to be brief, I'd say it's not necessarily a standard that's needed. It's really

a characterization of the limits of these constituents that that can be handled and tolerated to ensure there's no safety concern introduced it. I don't think there's any one answer you know across the board for every operator, but we can certainly you know initiate the research to determine what is safe and you know what impacts can be experienced by each constituent.

Schoenkin, Nathan (PHMSA)
And Dave.

David W. Murk
Yeah, I from again a standards perspective, this is not something that we would necessarily look to have a blanket standard across the industry. It's not something right now we're looking at from an API perspective. But yeah, no. I tend to agree with Sonal on this one.

Schoenkin, Nathan (PHMSA)
Alright, well, thank you all and Dave I'm going to keep you up there bcause I have another question for you. We may have missed it, it is: is there an expected timeline for a possible API standard on hydrogen blending.

David W. Murk
Right now, no and you know again the forum here over the next couple of days and where the R&D needs are, that will help inform the direction we need to go in a standard around hydrogen blending and you know again. The implications from an integrity standpoint from materials design standpoint that's kind of where we're going to be focusing so what are the implications of hydrogen blend so for us there's not like necessarily a hydrogen blend standard. It's there's a lot of component parts so to speak where we'll have we have standards that address certain aspects of integrity that would be updated around the implications and the challenges associated with hydrogen blend if that makes sense.

Schoenkin, Nathan (PHMSA)
Alright thanks Dave,

David W. Murk
Yep.

Schoenkin, Nathan (PHMSA)
Any further questions I have none in the chat so I'll give an option out there and Massoud would you like to proceed well actually we have another question so I will I will hold on that for a moment?

Tahamtani, Massoud (PHMSA)
Go ahead Nathan.

Schoenkin, Nathan (PHMSA)
Well sorry that is not a question that is a comment so then would you like to ask those questions I can ask the questions what's your preference?

Tahamtani, Massoud (PHMSA)
I'll ask the question. Which is, what emerging fuels do you all believe will present the most difficult integrity challenges for our existing pipelines. Nathan you manage thewho can go first.

Schoenkin, Nathan (PHMSA)
Sure Sonal, let's start with you.

Patni, Sonal
Sure, so I'm going to give you an optimistic answer Massoud so I would say hydrogen. But I'll say that you know as whether it's us here in the United States or specially what we've seen in Europe as we you know go from dipping our toe in the water to actually swimming in the water and get more research. You know when we were having these discussions several years ago about hydrogen blending and we were looking at like up to 5% what we even heard on the previous panel and as well as with the work that AGA's been doing on their white papers. It's now looking like 20 sometimes, 25%, blending so I think there are definitely challenges with leak detection and making sure that from a safety standpoint in a monitoring standpoint that we continue to function optimally but I do think it is optimistic that we can have like higher levels of blending so I'd say hydrogen. But I'd say that there's still a lot of opportunities and optimism there. At least what we've been seeing with the research that keeps coming out.

Schoenkin, Nathan (PHMSA)
Alright thanks, so now Steve. If you'd like to comment.

Steve Squibb
Yeah, I have to agree with Sonal. I agree totally with hydrogen. Not much to add there just from a safety standpoint of I'm thinking about our workforce in the field. It's a new fuel for them as I think David mentioned the workforce development side of that should not be ignored and need to educate our employees on all at that means to keep the communities and employees safe.

Schoenkin, Nathan (PHMSA)
Thanks, Steve. Shawn.

Miller, Shawn (BHE GT&S)
Yeah, I would agree that hydrogen probably edges out RNG, though it's you know, I don't want to get lost and the fact that you know, RNG is not a monolithic thing you know it depends on the source and you know kind of constituents can vary greatly. So, it presents its own challenges. But I think hydrogen is probably the more challenging of the 2.

Schoenkin, Nathan (PHMSA)
Alright. Thank you and then finally Dave.

David W. Murk
Yeah, I have the luxury of going last on a question like this so I'm going to agree with Sonal Steve and Shawn and the hydrogen front at least from the safety integrity standpoint, you know the other challenge is and I hope Cliff shows the slide he showed a couple weeks ago at a

conference that I was at with him where there's I want to say there's 10 or 12 different colors of hydrogen now there's pink grey Green blue and so you know the implications of developing hydrogen depending on the type of hydrogen as discussed earlier and then the CC US aspects of that and then the CO2. I think we have a better handle in general on CO2 and that infrastructure. I don't think so. It's challenging as hydrogen. But when you start bringing in the CO2 for capture you know it adds a whole new element to infrastructure for Hydrogen Development. So, I think that's just the added challenge that we face with hydrogen.

Tahamtani, Massoud (PHMSA)
Thank you Dave and I wanted just to pick up on what you said during your presentation that PHMSA is committed to continue to have these basically public meetings with regard to everything that we do our own making you mentioned the advisory committees and where we talked about in the agenda this meeting here all of these are very useful to all of us someone on the paddle mention that we have the best and brightest minds both within the government. The research sector and also the industry to make sure that our current over 3,000,000 miles of pipelines continues to stay safe and deliver the energy. We have now safely to our homes and communities and also get us ready for the for the future, and we're looking at some emerging fuels new fuels renewable fuels and and we have to be ready to of course, deliver those to our homes and businesses. I say that we had a public meeting back in May of this year and that was all about leak detection quantification and repair. And would that also as a lot of you on this call know the pipes act required the pipeline companies to not only take care of hazardous leaks, but also minimize releases, both fugitive releases and also vented. And here's a question to the panel what technologies you are aware of today, that your members or company uses that you didn't use 3 to 4 years ago to minimize releases, I would love for pipeline companies that are on the panel to go first and then and then the associations. Nathan again, you're back on putting people on the spot.

Schoenkin, Nathan (PHMSA)
Great. Shawn do you want to go first?

Miller, Shawn (BHE GT&S)
Sure, I touched on this a little during my presentation, but you know certainly that the portable compression has been the biggest game changer in in reducing emissions you know to the point where we've started out as a pilot. And we're using in I think out 4 of our pipelines to pilot that and we had some great success. We were seeing terrific end results and we've kind of made it as part of our standard practice now and even part of our outage planning process. We've completely embedded that in the organization now and then got a lot of buy in, it’s been terrific. Something else I'd say it's been so successful we’re actually looking at building our own and having a fleet of trailer mounted portable compressors to do just that. It'll be on that or even looking at facility modifications to make the ease of hook up. You know just reduce the time it takes to get these things installed and pump down to reduce the project time so it's, I'd say, that's the biggest one for me.

Schoenkin, Nathan (PHMSA)
Alright Thanks Shawn. We'll go on to Steve.

Steve Squibb
Yeah, I have to agree with Shawn there are 2 compression capturing that the natural gas is on our radar for sure. That's an intentional release of gas to vent your pipeline for maintenance or whatever so that's something we have control over and having the technology to compress and capture that. There's been new R&D efforts to when we place a new line in the service. Can we do that can we purge that new line with natural gas without venting gas on that application as well. So, there's been a lot of R&D effort in that area at APG has been trying to educate our members on at conferences and get that technology out there to educate the industry and I think that's the that's the biggest one to me is, is reducing the intentional releases of gas.

Schoenkin, Nathan (PHMSA)
Thanks, Steve. Alright now, Dave I won't make you go last again. So why don't you go ahead?

David W. Murk
Yeah, I don't necessarily have the background on the sensing equipment, but I want to hit on something that Steve just mentioned as far as intentional blowdowns and API. He is helping lead the environmental partnership and I can put the link up here, which is started out as an effort in the upstream production segment of our industry, which is now in the Midstream segment and focused on best practices around reducing league so another question from Massoud was more around the detection type of equipment, but you know, there are a lot of actions being taken by operators and particularly the programs within tap around natural gas pipelines are related to new pneumatic controllers where gas driven controllers are being replaced or removed from service. The blowdowns that Steve's looking at ways to reduce the number of intentional blowdowns that operators need to do in their operations and maintenance programs as well as well as the compressor program where we made changes to Rod packings on reciprocal compressors separating Compressors and things like that so I highlight that again that it's not only the sensing but it's also best practices and proactive work that the industry is doing to try and reduce the number of leaks from prone leak prone a type of equipment like Compressors and other things, so it's a different answer, but I thought I would throw that in there.

Schoenkin, Nathan (PHMSA)
Alright Thanks Dave, and finally Sonal.

Patni, Sonal
I don't know if I would say their recent in the past 3 years, but they're definitely gaining more momentum. We heard it mentioned this morning. The mobile methane detection. The use of drones. You know using those more accurate measurements for identifying leaks indoor residential methane detection breakaway meters again these have been in the works for a few years, but there's really more momentum around those, and those are great technologies based on if it works in your system and I will always caveat it with, based on what it looks like in your system where you're operating it's not a one size fits all but I'm sure Massoud is tired of hearing me say that.

Tahamtani, Massoud (PHMSA)
And never tired of hearing that. Is there another question Nathan?

Schoenkin, Nathan (PHMSA)
We have one final question so I will ask that one: Though I recognize the purpose of blending hydrogen into natural gas is to deliver a blended end product to customers are there any studies being done to potentially extract some of the hydrogen from the blend at the destination so the extracted hydrogen can be used for transportation purposes, i.e. fuel cell electric vehicles.

Patni, Sonal
So I'm not sure if I'm probably not as up to speed on it. It's really interesting there's so much energy up, no pun intended, and enthusiasm around hydrogen that I feel like every other day there's new research and new papers, which is wonderful. That's how we move the industry forward. I believe SoCal gas at one point was considering or looking at extraction of hydrogen. But I'm not sure if any of that is come to fruition. But I think at one point they were looking at that and I'm not sure if the person that asked the question is from SoCal. Just trying to get some more insight, but that's the only place I've heard it mentioned in the past.

Schoenkin, Nathan (PHMSA)
Alright, thank you. Any other thoughts. No OK Massoud, I think I'll send it back to you so we can close at this time.

Tahamtani, Massoud (PHMSA)
Well let me thank the panel members for their presentations and for responding to the questions and we finished a minute before I think so with that I'll turn it over to Bob thank you, Bob.

Smith, Robert (PHMSA)
Well thanks for that thanks Massoud and panelists. Let's move on to the next panel. So, panelists for panel 5 pipeline safety research partners, please be ready to unmute yourself when called upon. So now it's time for me to move to the 5th and final panel for today. So, let me welcome back Sentho White who I introduced earlier today. She's going to moderate the panel and the Q&A session following so Sentho go ahead proceed. I'll bring up the first presentation.

White, Sentho (PHMSA)
Alright thanks Bob and hi again everybody. There's been a lot of exciting discussion and presentations from the last 4 panels and our last panel's presenters are going to be representing the pipeline safety research partners and will be sharing their perspectives on how research funded by the pipeline industry is addressing the safety and infrastructure challenges with emerging fuels hydrogen and climate solutions and with that, we have 3 presenters to help us with that discussion from a pipeline Research Council international PRCI as well as operations technology development and also Northeast Gas Association, and so with that, I'm pleased to introduce our first speaker, Cliff Johnson, who is the president of PRCI, so Cliff go ahead, the floor is yours.

Cliff Johnson
Sentho, thanks so much for the introduction and thanks for the opportunity to be here today. This is a great topic, and he panels we've had so far really set us up and there's been a lot of commonality. There was a question earlier about with this collaboration lead into some

trademark issues and some trade issues overall. When you're talking about safety, there really isn't a competitive advantage. It's something that we need to do globally, and I think one of the things that affected it today that I'd really want to acknowledge is the globalization of this forum, bringing in the UK and Canada, to really show how fast and how big this issue is as I think it was mentioned a couple times in the previous panel. There's a lot of common themes that everybody is saying which again is awesome, because it shows where all aligning on those key opportunities as key research topics of where you want to go next. So why don't I give you a little bit of the PRCI or what are we doing in this space and how. We are assisting in the industry and this transition but also not to forget that we do still have current assets that need to be maintained for very long periods of time because we're still be using the carbon fuels for the foreseeable future as well so Bob next slide, please.

Let me start with our mission, so we've been we were founded in 1952 as a way to begin doing research, to ensure safety and integrity of our infrastructure. In the beginning, we were in natural gas. We've grown now to have a multi-faceted approach looking at the hazardous liquids the natural gas. The alternative fuels biofuels. All as part of the equation, including the facilities of our systems. Today we have over 70 members from around the world and we represent roughly 60% of the world 's transmission pipelines. To do this we've developed a framework where we collaboratively deliver relevant innovative applied research, for the global energy pipeline systems then underline a few words in that definition collaborative. It's important we pulled together, and we work towards a common goal to solve these issues because, as mentioned earlier, the previous presentations. Zeros our goal. We don't want any of our product to get outside of the line. That's not what we're trying to achieve. We want to keep this system that has strong integrity always through the process they want application, we want resources we can put into practice move into standards and to solve those key problems that I just mentioned and to look at that overall and then finally energy pipelines. It's for any energy source looking at the carbon based or the new fuse with hydrogen looking at ammonia or other things that are yet to be defined so that's what these systems are for this pipeline grid globally is the basis of our economy and basis of our future so. How do we ensure the integrity in the safety of these key assets moving forward ,next slide.

Let's talk about the emerging fuels first, and then I'll talk into the traditional program momentarily, next slide.

I'm not going to go over this slide in great detail. We've heard a whole discussion around the hydrogen push the renewable natural gas. And a question about which one is more challenging and rightfully so the answer hydrogen popped up a number of times historically in the Energy Pipeline Universe. We worked aggressively to keep hygiene out of our system because we know the improvement problem that we have is significant. Deterrence effects our systems. We've done everything we could to minimize the amount of hedging our systems. So now to introduce them into these mature assets is going to take some work, and some key research other renewable natural gas is mentioned by Shawn. It's really the constituent parts that are coming into a format that is a challenge, but that is addressable and something we could easily get our hands around but there's still other fuels that are out there that are coming in or have been in our past. Pearson was one of the thought leaders in research leaders on ethanol and biodiesel. But

there's also ammonia possibility as also as mentioned earlier today. CO2 is a key component for our future of our pipelines in our storage tanks facilities next slide, please.

This slide is kind of redundant for the rest of the day, we've had a good conversation or why the next looking at the environment to be that environmentally conscious organizations and groups and companies to reduce that impact that we have to allow us to be able to be more efficient and more effective again, keeping that product in the line any release is too much and we need to go out of our way to make sure it's not possible next slide, please.

We have a few statements on memorable natural gas, next slide.

The key thing here as I mentioned is really composition and just looking at what are the key components are coming into it. What's the feedstock for that real natural gas once we understand that feedstock and it's in behavior and how it may impact this deal, we can very easily modify and change and transition to what we need to be doing so, we feel pretty good about renewable natural gas more research point of view. We believe it's not too far from here to there to begin making that also we believe that rule natural gas is probably the biggest winch in the short term. To reduce methane ridiculous because here we're going to be using this current methane sources and we went into natural gas and that's a great way to begin reducing that footprint going forward next slide, please.

I mentioned hydrogen is some of those challenges that we have in the next couple slides will dig into some of those key issues housing embrittlement as I mentioned before this is the challenge. Is there probably number one. I think in the beginning and from the various agencies that spoke as well as the international partners. What material properties is one of those key research that's being done. Global Yousef at Dewey have worked at NIST. You've worked in a number of private research associations PRCI is also in that process. But we're supporting others were not create our own portfolio of research in this space. We helping to fund the DOD helping to fund other research organizations in this space because we all need to pull together and move fast little bit unique about this opportunity is that we're being told by when we need to be able to move on next product, so for hydrogen or renewable natural gas. Policy says depending on where you are in the world 2030 or 2050 a little bit unique. Usually, we have our own pace of research before we introduce a new product here we're being dictated to and driven so therefore, we must solve some of these cornerstone projects. It's cornerstone issues and these projects are being done by multiple bodies and so, if we don't bring them together in some sort of collaborative approach we're going to be doing redundant work, reducing redundant resources, and time and not advancing to the finish line as fast as we need to so we need to identify those key leaders in key areas identified opportunities to try things through those areas and then found others to do key things for PRCI and it means transport and storage. We look at the research. What we're looking for is whatever is based in that transport and storage of the conversation, so that's the area. We're going to spend all of our research time on but leveraging others who are doing something in that space as well next slide, please.

As Dave mentioned we have created a new initiative aside PRCI called the emerging fuels Institute and so this is a subset of the activities that we have currently in this space and so PRCI has this large research portfolio and we're going to carve out space to the emerging fuels and

we're enabling our members and other people outside of PRCI at two joining participate to help solve the problems that are out there for this industry. We want to develop a guidance document that helps understand for operators how to transition current assets into this next generation of fuels as we've shown earlier one of the presentations. If you looked at some of those dots that he had shown that the age of some of the pipeline systems in our country, there was stuff in there was over 150 years old. It was this cast iron pipe and not much of the Pearcey. But it gives you an idea there has been stealing the ground for a very long time. How do we now make this transition with this generation of steel into the next usable product for us? Number 2 we'll look globally across the world to see what's being done in this space and to really address those key challenges on a global basis. PRCI is into a partnership with our friends in Australia and in Europe to really drive that discussion of what's being done and how do we learn from the Europeans who are a little bit ahead of what we're doing here in the United States and to help leverage them work within partners with the Australians and continue to move down this space through this global partnership. You'll see the advances that we need for our industry. Both here in the United States and around the world. It's a phenomenal opportunity, next slide.

With the Institute we have multiple levels of membership and currently the highest levels Vanguard and these 6 companies here. I want to call them out because they stepped up and said, we truly commit to making a difference in our industry more coming. We just did it up just recently, so this is the first 6 who stood up and said let's make a difference. That's really taking charge and really help us get to that next opportunity, and to enable the industry to really grow in this in this area. Next slide.

Here's some of the key areas of research and again if you look at the various slide decks, you've seen already it falls really closely inline and so we were seeing the same kind of issues. How do we keep? How do we know? What kind of products we could put in various steel? How do we keep the hydrogen away from this deal? Is it creating some sort of barrier? What do we do for the facilities in the compressor and pump stations? How do we understand the underground storage challenges that we have with these new fuels? How do we store them effectively? All this is being considered by the emerging fuels Institute and will be aggressively addressed between 2022 hopefully. In 2027 the goal at the 5 year window to really begin with this space, next slide.

So that was the emerging fuels part. And I said it's important to remember that, we have assets we're going to be using for many, many more years, moving hydrocarbons and we have some set of challenges currently today as we talked about quite a bit leak detection and emissions. There are other things, too, that keep us up at night that we have to address again. Emerging fuels will be part of our ethos for a very long time into the future so while hydrocarbons and if so, we need to make sure the assets that we're using in both these spaces continue to pull this down that path. Next slide.

We'll look at the next 2 slides and just give you the idea that technical errors within PRCI. How we address research program looking at the compressor and pump stations looking at corrosion design materials and construction in the integrity inspection. These are 4 of the 8 that we'll talk about is really showing you what we need look at the full asset from the design of it to the decommissioning to the operations in the middle. How do you ensure the integrity and the safety

and all these key components and we have members and operator volunteers working in each of these areas to help us continue to move down this line. We've been very fortunate to partner with many people who have heard took today already for the trade associations through the government parties, including films that working closely with them to a Delta Research Portfolio. That helps our industry move forward into advance. The safety and integrity and throughout the entire asset next slide, please.

The last 4 are measurement and making sure we get the understanding what predicting from point A to point B surveillance operation and monitoring underground storage in sub c we have a growing interest in the subspace that kind of revitalizing the last few years as we look more and more for the deeper properties of how we bring some of the fuels from the offshore onto the onshore to effectively answer the questions that we have for the energy needs, next slide please.

Out of that core research program and we have a large number of projects currently active. We then develop some strategic research priorities are high value issues that are really pressing dairy industry and have been for some time. This work isn't something we just started these have been going on for a long period of time. The first one, is really looking mechanical damage. These are 3rd party strikes or interference with our pipelines but outside system and how do we understand this and how? Do we have the tools and responsiveness that we need to understand when these things are defective these defects or injuries to our systems? The second one is a key factor what we're talking about today and will be one of the panels that the next couple days are looking at the admissions, the greenhouse gases. How do we ensure that we keep the methane from getting out of the systems? How do we reduce those losses as much as we possibly can and the last one there number 3 is correct management, so between crack management and mechanical damage, it's really how do you have the tools to understand what the integrity issues are there then you throw in like I said the greenhouse gas, those 3 are current Research Strategic research priorities, which are vital to our industry to solve and address as soon as we possibly can will be completed in 2023 to really move us to the next level. The next 2 below the line are the ones that were in development currently looking at Geo Hazard and its impact. If you remembered the list that Sean Shield from Inge. This was one of their 8 hot topics is geohazards. There's a lot of movements that we know from the grounding but they're it's impacting our systems. How do we make sure we're ready for it and how? Do we prepare for it in the integrity side and as mentioned, many times today also has leak detection is something we've got to make sure so when things get out of the systems? We need to know as soon as possible so we can address those issues, if not before they could have as well. Next slide please.

Allen began his presentation talking about the research technology developments and other that PHMSA is working to create in PHMSA and not in public. Colorado and it's something that's on the shelf as you mentioned is a little bit slow to this development PRCI are already doubled up something similar on a much smaller scale than what they're going to be able to do in Pueblo. But so great, proving ground for our industry and for the tools that we have called the technology development center next slide, please.

NPR CI back in 2014 and 2015 developed and did some testing out of the failure that we had in Marshall, Michigan. Here we wanted to see what Caroline inspection tools do so NPRCI pulled together resources to little pull strings to test in my inspection tools understand their capabilities

were they able to meet some of the statements they were making and what's the next steps for advancement. So this is that facility here in Houston that allows us to do just that, next slide, please.
So, in the next slide will be talking about some of the assets there at the TDC is really what the goals were is trying to get into it, so that began looking at how do we advance our sensor technologies? How do we continue to push the envelope in that space looking at deployment packages? How can we make these things once we developed the sensors? How can we effectively get into those spots we need identify and track through we've also seen a huge opportunity for training qualified professionals? People who have been working on our systems to help verify the integrity and the safety also have a key role understanding what needs to be done in the TDC. Providing that opportunity and then finally a technology incubation center to allow some of the new thoughts and new companies to come up to use the technology that we have there based off the industry samples that we've contributed. The cornerstone of the DC is a huge inventory next slide. A huge inventory of samples that really allow us to understand what we're doing, and where we're going, so we have about 1500 samples from around the world real defects that allows the tools to be able to test and be verified up to that level. We're able now to put pull strings together between 6 inch and a 40 inch to test the tools in their capabilities, next slide, please.

Then we have a flow loop that allows the tools to be propelled by the water internally inside the systems and we've been able to do a 6 attend in a 12 inch to be able to test tools and their capabilities like never before in our industry. Next slide.

And so I encourage you guys get a chance like I said, this is kind of a baby. That's a decision what PHMSAis trying to do what we're trying to do so much smaller opportunity. But it has robust computer abilities. So, I encourage you to come spend time in Houston to learn some more. I believe it's the last slide, next slide.

And so the last 2 slides what I've done here and I'm not going to read through them because the time is this is a list of all the opportunities that we see to collaborate with PHMSA and other people in the room. Today, is what's next? Where do we need to go? How do we need to solve some of these key problems and mixture of what we need to do to help us move in the emerging fuels, but also so we need to do today for the current assets to make sure we don't forget about them to ensure the safety and integrity and that we do achieve zero is our goal so next slide, please.

And then our final slide Bob. So with that I'll stop at that time, and I appreciate the opportunity to speak today. Thank you again for the opportunity to look forward to discussions later on, I turn it back to you now. Thank you.

White, Sentho (PHMSA)
Alright, thank you Cliff and I appreciate your presentation. There's a lot of similar themes and the work that PRCI does and what a lot of our partners that you've heard from earlier this afternoon are working towards and so it is my pleasure to introduce our second presenter who is Michael Adamo and he is the vice president of operations for operations technology

development and Michael will be summarizing the research efforts taken by and supported this panel subjective and so Michael I'll turn it over to you.

Michael Adamo
OK thanks, Sentho, I appreciate it good afternoon, everyone. As Sentho said, I'm Mike Adamo. I'm the vice president of operations for OTD. Today I'll give you guys a brief overview of who OTD is for those who are unaware and then I'll touch on some of the work that we're currently funding and participating in that's relevant to some of the research goals that this forum has set out here, so this next slide, please.

So let me briefly explain the relationship between GTI and DOT for those who are unfamiliar with GTI. GTI is a nonprofit research and development organization that does R&D for really the entire value chain in the natural gas industry. It's been around for over 80 years. We have an exploration and production group that works on things like optimizing well fracking and its environmental mitigating its environmental impacts. We have a delivery group that focuses on research related to the transmission distribution and storage of natural gas. We have an end user group that focuses on end user equipment things like natural gas appliances, natural gas vehicles and we also have an energy conversion group that focuses on gasification of biomass. GTI manages several collaborative research organizations within it's sort of corporate boundaries and then also we have some separate industry organizations that GTI manages one of those is OTD which I'll be talking about today. But we also have UTD, which is utility utilization technology development. A separate standalone organization. Emerging technology program and then also LCRILC our newest collaborative that's out there and it's LCI stands for low carbon resources initiative. It's in was formed in partnership with Epiri The Electric Power Research Institute. And currently it has over $100,000,000.00 plus program focused on the development of technologies to enable the adoption and use of low carbon resources across the energy industry as sort of. We transition as sort of. We're in this energy transition towards net zero. But today, I'm going to focus really on on the collaborative OTD and so, if you can go to the next slide.

So OTD is a separate standalone nonprofit organization, it is member controlled where gas utility companies work together to develop technology solutions and common issues. We have 28 members in the organizations entirely controlled by those 28 members, so there's a board of directors. Each member gets a board member and that each member has sort of a technical project committee member. Everybody pays annual dues into the program those are calculated at 50 cents per meter per year. Much of that is rate recoverable dollars, most of our members have. rate recovery within their very states that they operate in. And then each of those members picks and chooses the projects we want to fund sort of by boating with those dollars on ones that are of most interest to everyone. Whether or not a member funds a project individually, everybody in the end has access to all of those projects. So, it's really good collaborative environment. You can choose the projects that are most meaningful to you and your company. We have members from sort of all over all over the country. Some people have cast iron some people don't. The nature of the projects sort of made depend regionally or on the makeup of your gas systems, so next slide, please.

The mission of the organization is to identify, select funds, and oversee research projects, resulting in innovative solutions and the improved safety, reliability and operational efficiency of

natural gas systems. So we really exist to try and enhance the safety of the natural gas systems to enable our member companies to you know operate more efficiently and effectively to minimize the environmental impacts of the natural gas systems and also to practice good science. There's a lot of manufacturers or folks out there that claim their technologies do all sorts of great things but it's important to really vet those out. You know the performance of technology out there and in a scientific manner next slide, please.

So, these are our member organizations like I said, we have 28 member organizations. Many of these are several of these companies are participating and leading some of the breakout sessions tomorrow, so thank you. To those folks who are on who are doing that and for your sort of intellectual and financial support of our projects. A lot of the projects that OTD funds, you know, we also like to co-fund PHMSA projects as well. Our interests are aligned greatly with the needs of things in the organization and as a result, we end up co-funding a lot of the projects. Next slide please.

So, our technology focus areas. This is sort of the way we organize our research. We have really 3 different working groups: the first one we call smart utilities. That's really our sort of GIS related projects or geographic. GIS GPS related projects. New sensors data management electronics for the gas system. We house all those projects in that working group. Risk integrity and environmental matters. We've done a lot of historical research on dimp timpe storage risks integrity projects. We've developed and tested and funded pipeline inspection technologies and then environmental matters methane emission measurements and quantification studies. We've had, and I'll talk about those in a future slide. But we've had sort of have a long history of funding those projects we tested various methane sensing equipment whether that's field used equipment or things like residential methane detectors and that sort of thing. Then we have infrastructure and gas operations, and this is where we develop new tooling and equipment evaluate new materials tester developed new operations and procedures. Next slide please.

So, with these next couple slides, I want to focus on a couple of topic areas that are relevant to sort of the breakout groups we will have tomorrow. One of those is focused on hydrogen, fueling I know we talked a lot about it to today, but I wanted to highlight a few of the projects that we have funded in the past. OTD funded a significant amount of research historically in hydrogen space. You know we've looked at impacts of hydrogen blends on pipeline materials whether it's polyethylene at various pipeline steals. You know, we have a number of completed projects in this space and as well as some ongoing ones. We have research projects. It looked at the impacts of hydrogen blends up survey equipment and gas analyzers. I know there was some discussion about that class session and then through our SMP program, we've also looked at impacts of hydrogen blends on various residential and commercial combustion equipment as well. And then at the bottom of the slide there, in addition to those projects that are funded through OTD, I have presented some various other projects that are currently being worked on at GTI, just to give some further context to the breadth of research that we're doing sort of in the area. Next slide please.

And so, we heard this morning from a number of the Department of Energy offices on their panel earlier today, and I just want to point out you know GTR 's participation in several of these projects that they touched down in one in particular. I want to highlight the high blend project.

OTDs providing a significant amount of cost share both cash and in kind to fund this effort, so some of the past projects and ongoing projects. We're working on that we mentioned on the previous slide are going toward co-funding this project you know the high blend efforts have fairly large effort. It's you know $14,000,000.00 in total funding 10 of that I think is from DOE and the rest is from industry. Additionally, GTI is participating as a an industry Co-lead along with Stony Brook University to help provide and facilitate industry input into the project and then there's a variety of other projects at GTC participating in either as a partner or a lead that I've listed here as well sort of related to Hydrogen storage and in hydrogen generation as well. Next slide please.

And one of the breakout groups tomorrow is focused on methane reductions from construction operations. OTD has funded a wide array of projects related to methane emissions quantification methane detection and remote sensing. With a series of methane emissions. Quantifications projects working on updating emission factors used in the greenhouse gas inventory estimate for various pipeline materials. We've developed detection technologies and performed a wide array of evaluations of commercially available products. We looked at the use of technologies of those technologies on various platforms from drones to aircraft to ground vehicles and other handheld devices. And we've also developed and evaluated projects that can you know be used to mitigate methane emissions during construction operations, which is really kind of the focus of tomorrow's breakout group as well. Next slide please.

I believe Jack Lord will be presenting in tomorrow's cast iron breakout group. But I did want to highlight the repair program from RPE. This program is focused on developing technologies for a pipeline system that can be built or constructed inside of an existing pipeline as an alternative to sort of digging it up and replacing cast iron as a hopefully more cost-effective solution you know thousands of miles of cast iron still exists out there today. Which many of our members own and the replacement costs. You know if you calculate that out, it quickly rises into the to the billions of dollars. And so you know OTD is participating in the program we're managing the technical and their the technical and testing technical and technical steering panel and so we're really just sort of leveraging are the intellectual input from our technical leads and providing material support and industry input into the projects and performers. Some of the testing team, but Jack will present on this program tomorrow. It's really focused at sort of rehabbing cast iron systems. Go to the next slide.

Yeah, I believe that's my last slide, but I'd like to thank PHMSA for the opportunity to participate and to work together at this forum. You know OTD members greatly benefit from our collaboration as I mentioned before our needs and interests are closely aligned so thank you for this opportunity. And I look forward to answering any questions the group may have during the Q&A session.

White, Sentho (PHMSA)
Alright great thank you, Michael on those perspectives and very interesting to see that you guys kicked off with everything low carbon resources initiative very neat stuff there. I'll have the pleasure to introduce our 3rd and final presenter and that is Daphne D'Zurko. She is the executive director for a Northeast Gas Association and research and Daphne will be summarizing the research efforts taken by NGA. So Daphne, the floor is yours.

Daphne D'Zurko
Great thank you Sentho and thanks to PHMSA for the opportunity. We've had a long history of successful Co-funded projects with PHMSA that I think we got our first competitive award in 2004 and there's a lot of good stuff that we worked on together, we appreciate that leverage. We are 20 plus members around New York North America and within the northeast region really they're all over North America. Enjoy high leverage on the research dollar and when we work with the other agencies that helps us do that. We also are known for moving quickly in doing practical research. We are sub-organization within the NGA. The reason why the name nice searches. We were started in the 1980s as a group of New York companies and we were working on important initiatives about safety in the 80s and 90s and looked at Utilization. But in 1996, we converted to an all-voluntary program that's been pretty successful since then In focusing on primarily gas operational needs for our 20 plus members. It's an entirely voluntary program. Funding is decided on a project-by-project basis and our members pay a small annual fee just to get a seat and then they can choose as many or as few projects as they want so get them last. I'm going to jump past a lot of the fundamentals. I think some of them were discussed earlier today and the next slide I just wanted to show and I'm speaking to some areas that folks have already addressed so I just want this is a good sort of illustration of the key actions needed for decarbonization as you know nicer chat and be active in in the area of methane leak detection and emissions, particularly in advances in leak detection and quantification invalidation of 3rd party measurements on methane emissions. We try not to overlap with other organizations. AGA noted have been very active in LDC emissions factors so we haven't really addressed that but we've been really active in the first 2 areas. We're not really that involved in energy efficiency. Although we've done some testing for gas supplies because we have a gas quality program and appliances and today will focus primarily on a work in renewable natural gas and clean hydrogen. But I just wanted to show in fact, just today, I missed the morning session because we were giving a workshop to the New York Department of Environmental Conservation and the Public Service Commission, on how we're how we're merging gas safety with environmental concerns on methane emissions and we were educating them on a number of projects earlier today because of the interest by others and what's going on in methane emissions next slide, please.

So also being last time I decided I'd take a slide that was near last of a 50 plus slide presentation I made in May that I presented with the whirlwind of activities and Decarbonization and I used a lot of things that you all have been working on with DOE and AGA and individual members work. I use a lot of things to show that we really have a lot of proactive things in the gas industry to look at energy alternatives and at the end I basically wanted to say you know where we can really get to our goals so I feel like the overriding timeline is sort of a big picture. I mean, I've been in R&D for 30 plus years we've had things that we thought we'd take 5 years that took 10 plus years. But we still were successful. For example, are unpickable line of robots to inspect unpickable pipelines that we thought would take 5 years. It took 10 but it's been successful. Now, for 10 plus years physical funded that so like where are we now know we don't have time there's a lot of to do and as you heard earlier. Today, there's a lot of issues so the good thing is that renewable now. You guys have been researched for years I think the gas Research Institute did work on hydrogen decades ago. But now we're looking at how to use our existing infrastructure. So, our goals are set up there's a lot of North American projects plan. We see that the UK and

others have been doing things and maybe ahead of us in a lot of these areas, but now we have sort of these aggressive goals so from a research manager. That's been doing this for 30 years. We only have 9 years to get to maybe a a gut check and so I view 2030 as a gut check where we have partial reduction of carbon emissions where we know that certain things will work that we maybe go from Gray hydrogen, which I'm sure you talked about Methane reforming, to blue hydrogen where we're taking advantage of some of the carbon capture and other technologies to Green hydrogen, possibly in 2050 and maybe that's been retracted back now. I know California is 2045 binden talked about 2035 but can we really go. I mean, we all feel like by 2030 we need to sort of have a real sort of start to implementation and real sense of what can work and how can we get more economics involved and how we can scale. So I mean to me, this is sort of the potential timeline and if you go to the next slide.

Nice search who represents you know, 20, plus local distribution companies in the distribution sector sort of did its own road mapping to figure out well where do we play a role? Where we're not you know? We're not multi mill. We have a $6,000,000.00 program. It's not you know 100,000,000 or 200,000,000, but we have a voluntary program that generates on a year-to-year basis anywhere from 4 and a half to 6 and a half $1,000,000.00, so we've been road mapping and basically you know, we've been doing various gap analysis. We also appreciate some of the others have done PRCI did an excellent series of gap analysis that they shared that helped us and our members who also supported PRCI. We've been doing various projects related to the impact to the LDC infrastructure and I'll talk about them, but going forward. I mean, if you look at it, you need to know, not only just have the studies, but know how you're going to sort of monitor and measure what's happening in your system and there's been plenty of projects in the past, where we find out we not only have to measure things but we don't have the right technology to measure it so for example, siloxanes, which is a byproduct of some domestic RNG sources. We have to make sure we have the right limits for siloxanes in orange, but we're still working on how to measure those limits with the right technology. So, there's sort of a step stepwise fashion here where you have to understand the gaps. But you also have to understand some measurement technology. You have to make sure that you have your standards and limits set and then you have to standardize and implement those technologies. So, we sort of see this as progressive and overlapping and while we tend to focus on LDC and gas operations, I think we're also going to step out and look at you know big impacts to reducing carbon like: How can natural gas or energy companies at work that are in this LDC sector develop carbon capture or support carbon capture other areas like cement production, which really have to reduce their carbon emissions next slide, please.

So, I wanted to sort of cut to the chase. I have other slides about projects, but if we were just to focus today on the emerging fuels and not the other R&D gaps, which I think our colleagues are going to discuss in the working groups. I think we need to. There's a lot of issues and there's numerous companies that are working on this. But we don't really have a full inventory of knowledge gathering of all the impacts and I think over the next few years, that'll come together because so many people are working on it, I think there's a lot of laboratory testing which has been really good over the years of getting members together and working in live conditions in the field. It's so critical for field testing that road map had a lot of intermittent spots for field testing. I think that's a gap that will always be there that we need to really understand the best ways to field test, and I think it's hard to do this in a political setting, but we really have to

understand the economics of green energy. Whether it's renewable natural gas solar winds on carbon capture with renewable natural gas with power to gas whatever it is. There's a lot to say about the economics and we're at the early stages of understanding. All that and in particular, we talked a lot about hydrogen we feel that would be a great area for organizations like nice surge and others and put things into focus for example, a lot of people have done testing. It blended hydrogen at 20 percent or lower. We think we should start looking at where research is pushing the envelope. We should look at you know testing blended hydrogen at 20 percent and higher. We should look at some carbon capture options and advancing technologies to reduce methane emissions. Next slide please.

So, I just wanted to give you guys a sampling of the projects that are already ongoing on things I find in the mini workshops. We've gone to with things as there are lots of new ideas and new folks that come into it, and I think we have to set it up. But as sort of a baseline of what's going on. So basically I'm going to just talk at a very high level of projects that are either already ongoing or ready to go. This is one that we just completed sort of the planning for and the funding and it's with over. I think 15 members of nice search. But it's hosted by SoCal gas and we're going to help, to basically develop a living lab in you know in in in a facility in SoCal 's territory where we can test components and make sure that in operation. We can analyze and report the impacts of hydrogen blending so we a lot of lab testing. This is going to be based on some control testing and some typical pipeline components that are from their system so the expected outcome is basically not just the feasibility of injecting and blending hydrogen up to 20%, but we expect to go beyond 20% and have answers about how this will affect components in our natural gas infrastructure, and I know it's similar to other projects that we and others are doing. Next slide please.

So, we have some base projects that we've done in other areas for example, we've been working with Monel Census Center, a spinoff of the University of Pennsylvania to look at basically redefining the database of where human olfactory responses tumor captains or the hydrogen sulfides that we put in our gas and so for 3 years. Now we've been developing a database of not just the detection threshold where you know something is present, but the recognition threshold. We know that it's natural gas so we already have the methodology with Monel on this and so in 2021. We started working towards the same sort of testing with the impact of blended hydrogen So what you see, there is actually in Olfactometer, which is a very specialized device from, I think it's Sweden, that we brought in and we have you know a very formal set of tests with subjects with different ranges of smell capability and so we have a very sort of formalized process for developing this database, and by the way the detection capability of humans now that we have good equipment testing it is at a sub PPB level. So, it's quite precise and you know, we want to look at the impact of different blends of hydrogen so we got this started this year and we hope to have results available in June of 22 next slide, please.

So I think Michael Dommel mention this we funded GT because we also had done extensive work with GTI from 2005 to beyond 2010 on other natural gas supplies like LNG and other. gas supply constituents and at the time we did a very comprehensive study with GTI on the impact of those supplies on elastomers and I think the gentleman from a PGA mentioned that as a gap earlier so this last summer work has already been started. We used all the methodology that GTI and I search developed in the earlier project to determine if blending hydrogen into a fuel gas

will change the physical properties of elastomers. We actually started this in early 2020. We did some preliminary results and we tested to it's most common rubbers of our funders SPR, which is styrene butadiene rubber and then NBR which is acrylic nitrile butadiene rubber so SBR. NBR would test with Karen Crippin and her team in GT and there was one we looked at basically a number of mechanical properties like shrinking swelling creep and stress and we found one material that showed a reduction in elastic city at 60 degrees Fahrenheit, but had no other material effects and then we had found no effects on NBR. But that was only at one temperature and it was a preliminary test so in Phase 2 we're doing a range of tests. I'm sorry a range of temperatures in a range of pressures and the members are making sure that they get the various elastomers of interest to them in these tests. So, it's kind of building on a base program that that the industry already spent money on in the past and now we're doing, it for blended hydrogen next slide, please.

So, another interesting thing is in California and elsewhere there's been focus on methane emissions to the point of even down to the threaded connections in a regulator station or the threaded connections in a meter set so we've been looking at for a few years now. Whether we have to worry about a specific thread quality thread standards with its NPT standard at Ram PC standard. So, we've developed some expertise with how to measure emissions and leaks from threads and we're doing this now, the same project is now being expanded for weather blended hydrogen with its smaller molecule impacts the risk of leaks or the leak rate through threaded connections. So, we started that this year and we hope to have this near complete or a lot of good results by the end of December in 22 next slide, please.

So this goes to something we started because of natural gas residential methane detectors. We did a dispersion study with FRA in Rockville, Maryland. It looked at basically full-scale testing of how natural gas disperses in a home to see where we should ideally place natural gas detectors and from that work we have a huge database and a methodology. So, we not only have laboratory scale testing, but we have one room and 2 room full scale testing in a model home as you can see. And so, the point of this is to actually study the physics of hydrogen and map the dispersion of natural gas planet with hide up blending with hydrogen up to 100%. So you know hydrogen is 93% lighter than air and 88% lighter than methane and so basically we are characterizing the gas blend behavior. Good news is that to date we haven't had separation even though there's a dispersion. That's faster of hydrogen reaching the perhaps the ceiling of a of a room. The methane there hasn't been enough separation. We have basically at this point at concentrations up to. I think it's 20 to 30%. We have homogeneous concentration, so this is not a completed project yet, but it's coming to completion and we have for our members. There's a graph there. I'm not going to run it, but basically shows in live video how that change happens with hydrogen versus methane. In these in these sample tubes and then in the home, so we have a graphic on that, but this is a completed project that we did with union gas now part of Enbridge basically we looked at and RNG plant that already had processed wastewater from bio gas and we looked at those components of a of a regulator and a meter station and we basically had metallurgical analysis of disassembled components that they after they'd been exposed to processed RNG and we found no effect, so that's an example of a project. We started way back when it helps us today with orangey next slide, please,

We've tested residential appliances for the impacts of siloxanes. We've set a limit based on one particular worst case analysis one. One particular appliance had a worse case, but it's a conservative limit and it echoes what California technology panel had also set so that's another example next slide, please.
And we've also specifically for the members and the LDC community, we looked at trace constituents of RNG and we've developed a database and a test plan and we're now testing on on this trace constituents for RNG. Lastly, I think it's next last slide coming up. So, in addition, we have some other things related to looking at methanogenesis and using actual microbes. Stanford University has a particular microbe. That's a viable method for power to gas operations and that's great news. When we talk about intermittency and generation of electric powers. So, this microbial power to gas conversion to long term operation project is basically another form of producing RNG and we're excited about Stanford's developments there I think in a Phase 2 of that, next slide, please.

I mentioned siloxane measurement. This is an analyzer program. We went to Europe to look for analyzers that could really get the kind of concentrations. We needed to test for siloxanes and renewable natural gas. We found some but now we have someone in North America, helping us sort of redevelop it specifically for the price range in the size that we need for portable gas operations. Next slide please.

And finally like the first slide I showed this is a project that National Grid started years ago and we're finishing up the construction of it where we're comparing in live conditions. The use of renewable natural gas through segments of pipe to traditional natural gas and every year will be withdrawing segments and analyzing those components as well as doing chemical analysis on a regular basis, so this renewable natural gas living lab and Newtown Freak was an initial idea years ago that now is finally going after years of waiting for permits. And we're building the same sort of living lab for hydrogen with SoCal gas then when I discussed earlier so last slide, please.

I'm not going to talk about gaps related to the broad research. Although we're very interested in other broad research topics with PHMSA and others. But I would say that from the emerging fuel standpoint our members have been highly involved in the last 2 to 3 years and getting more people leveraging their funds to play a role in Decarbonization were impressed with all that everyone else is doing too. And it's just kind of hard to keep up with what everyone 's doing so, we have to keep those sort of literature searches and collaborative discussions going on like what I've experienced in my career, I think. The fast pace is going to be key research is not fast and if we tell people we're going to do something in 5 years and we don't know we really shouldn't say we can do it in 5 years because there's a lot of risk in research. But I do think that there's a lot of fundamental work already done and so that's why the government funding and support that I think we need is for things like field testing these living labs and pilot test pilot test for things that we're doing, but also things that others may be doing incorporate carbon capture and sequester sequestration and from reducing and eliminating methane emissions. So, I'll leave it at that time on the other working groups will talk about a lot of other research gaps or things that were already doing. Thank you very much for the opportunity.

White, Sentho (PHMSA)

Great presentation, thank you and very, very interesting perspective and loved the Living Labs that the nicer just developing as well as the you know, honest perspective on the timeline and for the carbon neutral and hydrogen road mapping that you gave thank you. And so, with that I will kick it over to Nathan for any Q&A from the chat.

Schoenkin, Nathan (PHMSA)
Sure, so looks like we only have 2 questions so the first one, I believe is for Cliff because this is the right time. It says so you are replacing with HDPE if not would you be installing with spacers if you are installed steel?

Cliff Johnson
Actually, probably better for Mike referred Daphne and I just do plastic pipe so they'll be best for them and that space. We do some work, but mostly there could be a lot more of that space.

Michael Adamo
Yeah, I'm not sure if that question was related to the RPE repair program. It may have been. That program you know that they're looking at a variety of different coding materials, so here's about 10 different projects performers. Each one has a different solution. Some of it is sort of a spray on metallic coating some of it. They're different composite materials that they're looking at so there's a variety of sort of new pipeline materials. They're looking to install.

Schoenkin, Nathan (PHMSA)
Dahpne, did you want to add to that or?

Daphne D'Zurko
No, I think that's appropriate thanks.

Schoenkin, Nathan (PHMSA)
OK and then has anyone looked at how hydrogen effects reciprocating compressor performance and equipment integrity. To whomever would like to discuss that.

Cliff Johnson
Yeah, when you look back at performances we've done some research PRCI, historically, we've got a good level knowledge on the performance that compressor and pumps. The integrity is a little bit different. We are doing some research currently with the gas machine. Your Research Council on the integrity of the equipment and so we'll be having that complete sometime next year as the goal. But on the performance like I said, we have some research already in hand that talks about that. We understand where that's looking at but the integrity as the next big question mark and so we're working with the GM mercy to begin developing some of that file finalize that project statement again. We're finalizing that project next year.

Schoenkin, Nathan (PHMSA)
OK thanks Cliff. Michael or Daphne do you want to add anything to that?

Michael Adamo
No OTD hasn't done any research. I think the DOE has done some stuff in it from the fuel cell

office and then I think that, obviously there's compressors reciprocating compressors out there on hydrogen networks today.

Cliff Johnson
Right. Yeah, so they're losing those as a kind of baseline is interesting because it's 100% hydrogen so as Daphne said, how do you go above 20% is that magical number? We all feel somewhat comfortable with that to 10 to 15. 20 gets a little bit iffy, but that's OK safely, but above that's where the question marks really began getting to the big issues and same with this kind of compressor performance, too, so we've done some because there's been some research done by DONPRCIN graphic out the DV stuff that's making that path bike and then the integrity side is that we're doing fresh now.

Schoenkin, Nathan (PHMSA)
OK thanks Daphne did you want to add on to that?

Daphne D'Zurko
Yeah, we don't really do compressor work, we've left that to the other guys.

Schoenkin, Nathan (PHMSA)
OK great and then finally are there any gas distribution areas like specific cities that have volunteered to act as a field test location for blended hydrogen into their natural gas system that you know of.

Daphne D'Zurko
So you talk about large cities or just anywhere.

Schoenkin, Nathan (PHMSA)
It just says specific cities so.

Michael Adamo
We there are a number of utility companies sorry Daphne to go ahead.

Daphne D'Zurko
I think the answer to that. Maybe not yet. Sorry. Well, we might be saying the same thing. There are companies that are doing pilots. There's lots of them, but they're not specific to a city that's my response.

Cliff Johnson
Yeah.

Michael Adamo
Yeah, that's same thing.

Cliff Johnson
Yeah, what you're seeing to that globally there's been some things done. There's a great quote Unquote hydrant town in Australia. That Atco and a couple of operators in Australia put together

similar because being discussed earlier today by the UK. He just indeed they have a great project program with DMV where they've built basically a miniature transmission and distribution if opportunity and then there's some operators and the US who had begun to build kind of similar things on the transmission side to begin looking at with the large transport of hydrogen so you look at the Williams and a couple others Atco and SoCal are looking to do a partnership here in the United States and kind of a hydrogen town so to speak so these things are beginning to happen. I wouldn't say there's anything like as though you guys, just mention there's nothing quite there yet, but there's a lot of things underway that are beginning probably next few years, will see more and more information about that.

Schoenkin, Nathan (PHMSA)
OK thanks everybody. I promise is the final one because we're going to try to close at 4:15 and want to give people some time to walk around it is the overall option of Grey hydrogen along with CCUS an alternative to blue hydrogen being considered or is the overall goal to blue hydrogen only especially with the great natural gas resource in the US.

Cliff Johnson
That's part of the question is where is the feedstock for hydrogen is the big question that's out there I don't know if anybody is landed on the answer at this point. It may be Daphne or Michael have a better answer, but I haven't seen who's we've selected yet for the hydrogen feedstock because each weapon right now have different positives and different negatives and it just depends where you want to go but there's some challenges with Green. There's challenges with blue and I just haven't heard anybody say we're going to pick this one and go that direction. Right now, at this point, I think we're all still exploring it hasn't the slider to the rainbow of hydrogen. I think everything is being kind of on the table because we just don't know the best way to get to the finish line. It's actually the other question is to not necessarily the production of hydrogen. But on the consumption side? How much is demand? How big of a demand? Is there and that'll help drive also some of the questions about what kind of production source. You want to do as well, which we haven't got that point answer, either.

Michael Adamo
Yeah, I think the only other thing I would add is you know the end goal really should be to mitigate as much carbon intensity as you can so what if you're able to do that through carbon capture after the fact and in an economical way, then the source of the of the hydrogen shouldn't matter. Just be the end carbon intensity.

Cliff Johnson
Yeah.

Daphne D'Zurko
Yeah, and I guess I would keep an eye on something you said Mike is that as researchers we have to look at all those paths, but with the time element important and the knowledge of how you know research usually advances is a TRL level and then retracts and advances and you know you just don't go straight forward. There are bumps in the road. I would suggest and listening to our members and business discussions is that at some point and this is why I had that sort of gut check a 2030 at some point we have to let economics help drive what's going to make sense

because we still have to reduce carbon and if we can't get the economics at all close there's not going to be take up if there's anything that I leave this industry. It's at deployment is where the rubber hits the road so.

Cliff Johnson
Yep.

Daphne D'Zurko
The parallel path, we have to do right now, but at some point we have to get serious about deployment in economics.

Cliff Johnson
Yeah, that's going to be the real challenge because again, we just haven't talked about that. The consumption side yet. That's really hasn't been a critical conversation at this point in the story because it goes back to right now in the bill has hubs hydrogen hubs, but where do you put the hygiene hubs and how do you? How do you do that and if it's in the traditional places. Some of the environmental justice questions come into it exactly because we won't put it back in again disadvantage places where we had before to have a huge production of energy so how do we talk through this in a very intelligent way and as Daphne said how you do it economically in a way that makes people incentivized to make some transitions in right now.

Cliff Johnson
There's some big questions, some really big questions, just before you run, I want to mention in the chat Jalen Kalyn, excuse me Caitlin Jensen from Atco mentioned they're going to actually run in 20% hydrogen outside the city of Fort Saskatchewan and Alberta in 2022, so that's going to be one of the larger cities that I know of that are not going to have that quote Unquote Hydrogen City.

Schoenkin, Nathan (PHMSA)
OK, well, I'll pass it back to Sentho.

White, Sentho (PHMSA)
Alright, thank you all and thanks Cliff Michael and Daphne on your presentations and all the Q&A for this panel and so with that I'll kick it back over to Bob.

Smith, Robert (PHMSA)
Sure and thanks for that. I was told that we are going to take a quick break and I'll announce that in a second, but just a few remarks. Of course, thanks Sentho and panelists. Cliff Michael and Daphne so that concludes all of our panel discussions for today, but hold on you know after we get back from the break, we're going to have 3 remaining individual presentations and of course, a wrap up on day one in German so I think with that, let's go ahead and say that we are going to reconvene at 4:25, so 25 minutes after this we will start with the next presentation about our competitive academic agreement program so I'll reconvene us at 4:25 or 25 minutes after the hour. Thank you.

Alright everybody thanks for hanging in there. We do have 3 individual presentations left like I mentioned. Kandi are you there just checking.

Barakat, Kandilarya (PHMSA)
Yes, I'm here can you hear me?

Smith, Robert (PHMSA)
Fantastic so the next presentation will be made by Kandi Baraket, who I've introduced earlier today. She'll be sharing information and activities about our competitive academic agreement program and about how PHMSA plans CAPP and advancing equity go ahead Kandi, you can proceed with the presentation.

Barakat, Kandilarya (PHMSA)
Thank you, Bob and good afternoon, ladies and gentlemen again my name is Kandi Barakat. I am operations supervisor at the engineering and Research Division. Today I'll be providing an overview of our competitive academic agreement program and some of the measures we have been taking with respect to equity next slide, please.

CAPP is an academic pipeline safety research and development program. Its purpose is to spur innovation by focusing on high technical risk and high payoff solutions. It exposes undergraduate and graduate students to research in the pipeline safety industry and cultivate new talent that began soliciting for R&D projects under cap in 2013. Next slide please.

PHMSA also lists and awards R&D under CAPP on an annual cycle. We will issue a notice of funding opportunities and those are typically announced in the winter months after the nofo is issued. The universities have 60 days to submit a potential project that is relevant to the topics in the nofo. When the 60 days are over PHMSA has a review process of all the proposals submitted within 60 days. The proposals go through technical and Programmatic Evaluation reviews and the projects are awarded within 9 months around the 4th quarter of the fiscal year. Next slide please.

Total CAPP yearly awards are approximately 2,000,000 individual CAPP awards are limited to 1,000,000 of government funding. And this is a change that started in 2021 previous projects were capped at around 250,000 and there is a statutory requirement of a 20% cost share for CAPP Awards. This is under Section 22 of the pipes act of 2016. Next slide please.

In this slide, I would like to emphasize that partnership in CAPP is essential as it fosters creativity and innovation in research. Whether it's between University with other University or partnership with industry. Next slide.

A little bit on that CAPP history PHMSA has awarded approximately 15.1 million dollars of federal funding under the CAPP program since its inception. Over 345 students have been exposed to the pipeline safety field through the program and 18 students have received an internship or some sort of employment in the pipeline safety industry. Next slide please.

This is just a visual to show that the CAPP program is spread out throughout the country. Next.

This is a slide of our recent CAPP awards awarded on September 30th 21, the first project was awarded to Arizona State University or asco. And as he will be working to develop an artificial intelligence enabled framework to 8 existing pipeline operators with their pipeline. Integrity management programs as they shift towards the use of emerging fuels such as hydrogen. The second project was awarded to Rutgers University. Rutgers will be developing an artificial intelligence enabled probabilistic performance model, which will aid operators in their inspection and repair action decision making process. The 3rd project was awarded to Colorado School of Mines, Colorado School of mines will investigate the feasibility of using distributed acoustic sensing cables, to detect and locate pipeline integrity risks using different cable deployment methods. Specifically, Colorado School of mines will be investigating the use of internally deployed cable to minimize the cost of pipeline excavation for cable placement. The 3 projects listed above accounted for approximately 1.9 million dollars of funding. Next slide, please.

Now I'll talk a little bit about the presentations that will take place tomorrow. Next slide.

Tomorrow, various universities will present about their CAPP research projects that took place there will be 9 presentations conducted by 7 universities and those presentations will occur between 1245 and 245 Eastern Time tomorrow. The main page where you're registered to attend the event will have the links to the various presentations. So just click on the ones you are interested in attending. The presentations will occur simultaneously, but some will offer 2 presentations in the same time frame. Next slide.

I won't read the list of the projects here that will be discussed. I just want to highlight the universities. Arizona State University will be presenting on those 2 topics and the second one for Hydrogen Transport. This is the one that was recently awarded. Georgia Institute of Technology will be presenting on this topic. Next slide.

University of Texas at Austin, Missouri University of Science and technology will also be presenting on those topics, next slide.

North Dakota State University will be presenting on 2 topics, which are shown here. Next slide, please.

Marquette University and University of Alaska will be presenting on those topics. And if you have any specific questions about those projects. Please reach out to the presenter tomorrow with any detailed questions. Next.

Now I would like to transition to equity and how it impacts CAPP. Next slide please.

As Sentho mentioned earlier today, DOT has 5 pillars and equity is one of those pillars. Executive order 14041 White House initiative on advancing educational equity excellence and economic opportunity through historically black colleges and universities. Under this executive order PHMSA thrives to implement equity to CAPP by expanding the outreach to minority serving institutions and we thrive to increase the participation of minority serving institutions

and the CAPP program. We are currently conducting a gap analysis to identify minority serving institutions and their research capabilities. Next slide please.
Minority serving institutions are identified as HBC or historically black colleges and universities. Aand API SI or Asian American and Native American Pacific Islander, serving institutions. TCU tribal colleges and universities or TSI Hispanic serving institutions. And those are based on 4 year college and as you can see, there are over 300 of those minority serving institutions. Next, please.

On January 20th 2021, President Biden signed executive order 13985 advancing racial equity and support for underserved communities through the federal government through the implementation of this administration priority. DOT undertook a comprehensive approach to advance racial equity for all including individuals who have been historically underserved and adversely affected by persistent poverty or income in addition, I'm currently serving on the equity and technology and Innovation Task Force for this initiative. I have regular monthly meetings with other DOT modes to discuss the various measures each mode is taking to implement equity into their program. We're currently compiling a list of questions and resources that impact equity and will be conducting some sort of an equity assessment in the future. And last slide, I believe I have one more slide.

So, for those of you that don't know I joined things a little over a year ago. I am inspired by the robust team here at PHMSA. Sentho White is the director and a huge shout out to Robert Smith R&D Program manager and Nathan Schoenkin and senior engineer. They are the pillars of the R&D program. We also have 2 secretarial interns. Nouri trottenberg and Lindsey Sonnefeld, who joined over the summer, they have been an asset to the R&D program. Thank you.

Smith, Robert (PHMSA)
Well, we potentially had any period of Q&A.

Schoenkin, Nathan (PHMSA)
So we currently have no questions in the in the chat box. But if anybody does have any questions. I'll give everybody a few seconds here to go in and put questions in the chat box. So, we have one question from signal generally repairs and remediation are based on risk is the proposal to now include equity.

Schoenkin, Nathan (PHMSA)
Kandi do you want to take that or I can?

Barakat, Kandilarya (PHMSA)
Maybe that one is for Sentho.

White, Sentho (PHMSA)
Sure, so one of the working groups actually working group number one has to do with you know remediation repair and as you know, many of us have mentioned throughout the R&D forum a lot of the aging cast lines are within urban areas that are within and you know, sometimes underserved communities and so there is a bit of, I would say influence in terms of equity with respect to the location of these lines, but it's not just within urban areas. There can be also rural

areas that have underserved communities. So, we are actually going to be looking into this in more detail and hopefully the Working Group tomorrow will help to inform some of that decision making process for our future or in the agenda.

Schoenkin, Nathan (PHMSA)
Alright Kandi we have no other questions at this time.

Barakat, Kandilarya (PHMSA)
OK.

Smith, Robert (PHMSA)
Alright well, I guess I'll jump in then. Thank you for that Kandi. I appreciate it; let me bring up my points here. So thanks for that overview and about how our efforts to advance equity through the research program should be possible. So before I move on to the next just want to make sure Lauren is there.

Lauren Tipton
I'm here can you hear me?

Smith, Robert (PHMSA)
That's good well, let me have a couple announcements here and I'll kick it over to you.

Lauren Tipton
Sure.

Smith, Robert (PHMSA)
So it's my pleasure to move on now to our next presentation and introduce Lauren Tipton. She's representing the young pipeline professionals USA. We thought it was a really good idea to add ypp to our agenda since we had an opportunity here to share information to a large audience about this great organization. Lauren is principal at elemental compliance and will be introducing many of us to ypp an organization guided by senior professionals run by young professionals and focus on advancing the careers of young pipeline professionals. Lauren, please tell us more and proceed with your presentation. Let me go ahead and bring it up.

Lauren Tipton
Great thank you. Thanks for having us we're really excited to be here. Like Robert said I'm Lauren and I am the secretary for young pipeline professionals USA. That's a 2-year position. Previously, I served as a workgroup lead for membership engagement and coordinator, so I'll just kick it off. It's pretty quick. But we wanted to give everyone here and idea of what ypp USA is all about how we're serving our membership and what some of our goals are so we can go ahead and go to the first slide.

And we were formed with the mission of educating connecting and developing the future leaders of the pipeline industry. Actually, originally developed in 2015 as a volunteer organization our main goal is to prepare ourselves to accept the duty of care for the pipeline industry as we know a lot of our experts are retiring or will be soon retiring and we identified this as a gap that there's

a lot of knowledge that would be leaving the industry and we wanted to prepare ourselves to accept that so we formed this organization and it's been growing a lot, especially in the past year and we were formed to educate our young professionals about the pipeline industry. We are really focused on providing valuable educational webinars and events, we create leadership opportunities both within our organization and we facilitate other leadership opportunities that are presented to us from other organizations, and we foster relationships and build a network for the advancement of the industry. We recently added an option to or a goal to promote diversity and inclusion as leaders within our industry. That's another gap that we've identified and that is really important to our membership, especially including a lot of Millennial and Gen Z generational folks, next slide.

And we've grown tremendously, especially in the past year, we've over 300 active members now across 26 states this includes all different kinds of organizations from service providers to actual pipeline operators, vendors, and consultants and we even have a student opportunity for students to join we have local chapters that are located in Houston, which Houston is our biggest chapter Tulsa Columbus and Atlanta, Georgia. Next slide please.

And the value of membership this is what typically we present to our membership as the reason that they should join is these bulleted. So technical presentations are really the backbone of what we do, we've tried to provide one at least monthly with the advent of Covid. We've been doing zoom webinars presented by experts in particular fields presenting on a topic and then give our membership, the opportunity to ask questions. We typically do it around lunch time as a lunch and learn and membership now that it's coming a couple weeks in advance. We host our symposium, which has been every other year. That's coming up in April of 2022 and that will be hosted in Houston. That said a conference style event that is planned organized and attended by young pipeline professionals again, we do similar to this, you know, we have folks that will present on this specific topic. Our focus this year is our energy future, and our focus will also include different carbon neutral industry events key topics about hydrogen in the pipeline feature of Pipeline Integrity Asset. Security latest technologies that are being implemented. So, we definitely have an eye on the future, and our symposium is going to reflect that. We host bridge workshops, which are more like an in-depth half day event, where we'll pick a particular topic and do a deep dive. We have picked hydrogen in the past for that, so that kind of fits into what we're discussing today. We have leadership opportunities like I said within the group. You can either be on the leadership team which is a 2-year position or a workgroup lead, which is a one-year position. Both of those just serve different aspects of our membership. For example, we might have a diversity inclusion chair. We have membership engagement; we have advisor relations. That sort of thing.

We were doing site visits and we do have a goal set out for our local chapters to do at least one site visit every year so that our membership can meet up and network with other folks in their actual area. And then we also provide discounts on training courses that are offered to us and next slide, please.

So our symposium is our big event that's coming up. We have a lot of energy going into planning this that was going to be in Houston in April of 2022. We already discussed our keep topics there, but we could really use the help of the industry in planning this we have a lot of different

opportunities to help primarily that would be sponsorship. We're looking for sponsors right now and folks who can help financially to be able to make the event a success, but we also are always looking for presenters. People that are you know have a specific knowledge base and could present something valuable to our membership, either at the symposium, or through our webinars that we present every month. And so we would love to talk to anyone about that. Our information will be at the end. And if you're interested or you think your company might be interested, please reach out to us. And we can go the next slide.

We talked a little bit about what ypp is now we'll talk about what we are not. We really put a lot effort into resisting these things we don't want to be like approaching ground or an opportunity for recruiters or other employers to come in and kind of put away or membership. We don't post any job opportunities. We don't provide our contact list to anybody, and we don't endorse specific products or services. We do try to endorse things that are given to us. We will you know spread that information around membership, but we don't pick one specific topic and endorsed that next slide.

So who can join and you have to be no more than 35 years of age in the year that you apply for membership. If you apply at age 35, you do get a 5-year grace period. So, if you're 35 or you're close to 35, you should go ahead and join because you still get a few years of membership to get some of those benefits and the only other requirement is that you are either employed or seeking employment in the pipeline industry so either an owner operator service company vendor consultor consultant anything like that and we also have that student membership opportunity, so if you know a student who might be interested in joining the pipeline industry or is in a field of study that may serve the pipeline industry, they can join as well. The cost is free. There's no fee to join remove that a few years ago. We used to be a paid membership. But that is no longer the case so you can just go to our website and click join and you fill out a little application and then our membership engagement coordinator will approve those memberships. Absolutely think about joining. We love to have any young professionals who you think might be interested. It's a great networking opportunity. It's a great leadership of our community, I've really enjoyed it. I've learned a lot and I went and met a lot of folks that are young pipeliners, which is sometimes hard to do, if you're you know in one company, so it's been really, really great. We love to serve our members next slide, please.

We also have a few other activities that we're going to promote a little bit after symposium as well. We're going to moderate model or mentor ship program after younger young pipeline professionals Canada they have a really great program. That's been a very great success with them. That's another way that folks who may be beyond the age limit that want to get involved. You could join that way where we're kind of soliciting folks to be member mentors to our membership and you could take on a young professional and kind of guide them and help answer any questions that they might have. We're also getting involved with our local University so this is we've started with the University of Houston, just getting plugged into some of their groups and trying to spread the good news about pipeline as a job. We're also exploring new industry events and new companies in the hydrogen and renewables space to prepare ourselves for some changes that may be coming to industry and then on top of that. We added new workgroup leads so those are additional leadership opportunities, which is local chapter Liaison University and

mentorship like we just talked about and then industry liaison, which might lead with like inga or API or something like that. Next slide please.

And that is it so if you are interested or you know anyone who might be interested in joining please go to YPUSA.Org there's Big Red Button on the front page that says join here as I said it's free fill out your information. We'd love to have you and it's a great time. Everyone is really nice. And we would love to see you at our symposium in April and if you are interested in sponsoring or in some way assisting us with our symposium that's coming up. Please reach out to that email, I will likely be the one reading it or Art or a chair, so we'd love to hear from you and we'd love to collaborate with you so thank you very much to PHMSA and thanks everybody for listening.

Smith, Robert (PHMSA)
Lauren thank you very much for the great overview. I know Alan Maybury and myself had the honor to participate in your inaugural workshop. I think Allen is also participated in advisory role for ypp and I know I participated in one of your webinar online presentation. So, it's a great opportunity to participate with ypp and I urge anyone attending and seeing this to go to the website and find out more.

Lauren Tipton
Yep. Yeah, thank you.

Smith, Robert (PHMSA)
Alright. Thank you for that let's move on to our final presentation for today. Sentho White is going to be returning and summarizing about the 6 work groups that are going to be happening on tomorrow's agenda. Sentho, let me go ahead and bring that presentation up and then have you get started?

White, Sentho (PHMSA)
Alright, and I see it's up and so I'll make this very brief since we've had a long virtual day in our home offices and I'm sure you all are ready to rest your eyes from staring at the computer screen and would like to continue with your evenings and so at that time, please proceed to the next slide Bob.

And so I'll just give an overview of tomorrow's a working group, so we plan on having 6 working groups that will be running concurrently and they're going to start around 10 and each of these working groups actually requires pre-registration number actually capped at 60 people in order to make sure that there's really good discussion within each of the working groups and the working groups will be publicly reporting out their findings on Thursday, December second and if you can go to the agenda, it's listed there on the slide, you'll be able to see those report outs as well after Thursday 's meeting and each of the working groups that are going to assist and develop their research agenda for the coming years and the working groups, of course, they're going to be all virtual but we're also going to have contract support in helping to facilitate and making sure that everybody 's ideas are captured in this collaborative space ,next slide, please.

So we have 6 working groups and as shown here and I'm not going to go into each one if you can go to the next slide Bob please.

PHMSA Working Group one, as we've mentioned on previous presentations is a rehabilitation of aging casts are in pipelines and in this working group, we're going to explore R&D topics that would advance technological solutions to rehabilitate and repair agent casts are in lines. Next.

So the working group one, it's going to actually be led by both PHMSA and an industry Co leader and our PHMSA leader is Chris McLaren. He's a program manager within OPS and the industry Co leader is Saddat Khan. He is the director of gas distribution asset, and Engineering Nysta with National Grid.

Our second working group is going to be focused on the integrity of underground natural gas and hydrogen storage. And here we're going to be seeking solutions so advanced as safe underground storage of gas and blended hydrogen with natural gas and of course. This is going to be focused on reducing methane emissions from underground natural gas storage facilities.

And Working Group 2 is going to be led by James Pfeifle. He's a general engineer and program manager with PHMSA as well as 3 industry. Co leads and those are Anders Johnson, BP gas storage with Kinder Morgan Gordon Lloyd, who is the project engineer in the combustion turbine group for Northern California power and Hillary poetry, so she's a project manager with a hydrogen engineering strategy axle Cass.

And for Working Group 3, the topic is going to be on utilization of inspection tools on hydrogen pipelines. And here we hope to get advanced knowledge on the impacts of hydrogen and blended hydrogen concentrations on inline inspection tools. And this working group is going to be led by our leader Christian Selu and he is a pipeline safety inspector within OPS and 2 industry. Co leads and that is quite smart with Pipeline Integrity. He's a pipeline integrity engineer with bhe GT and S as well as Greg Vanboven and he's a senior engineer within innovation and decision Optimization Department of a TC energy.

And our 4th Working Group is going to be on hydrogen network components and I'm sure this one is going to be quite an interesting discussion based on the various presentations. We've heard from our various panels earlier today. And the Working Group leaders are going to be led by our very own engineering and research engineer at Benny Holohan as well as 4 industry. Co leaders and that's Mirella, Haiti, she's manager of energy transition technologies with TC energy. Also, Tim Harris and he is an R&D senior engineer with Southern Company. There's also Kevin Woo who is the hydrogen strategy team lead with SoCal gas and Danielle Mark, who is a senior gas engineer with PG and E.

And a Working Group 5 is on methane mitigation construction and operation and I'm sure this one is also going to be a very interesting Working Group and here of course, the discussion is going to include reduction in methane releases during construction and maintenance cities. Maintenance activities such as when a pipeline is purged prior to putting it back into operation and also after lines are taken out of service. And this working group is going to be led also by another member of our Engineering Research Division, Steve Nanny. He is our senior engineer and also industry colleagues include Zach Keith and he's manager in environmental services with the Williams company Adam Stickle, who is a materials engineer with Washington gas and Nick Medina, Public and government affairs manager with Exxon Mobile Pipeline Company.

And last but not least, we have our 6th Working Group on breakout tanks and methods to prevent corrosion of tank bottoms. And here on this working group is going to be looking at a new corrosion control techniques that could be used to improve leak detection of above ground storage tanks. And this working group is going to be led by another PHP 80 engineering and research division members, Obedi. He is a general engineer as well as 3 industry. Co leads and that will be a Chris Aldric, he has integrity management program coordinator with marathon pipeline. Justin Samuel, who's an engineer in integrity Tech services with Phillips 66 and John Field, who's a corrosion engineer with energy transfer partners.

And on behalf of the R&D team, I want to thank all of the PHMSA and Industry Co leads on their hard work and contributions on developing these agendas for the working groups and identifying presenters, and I know that many of us are going to be looking forward to joining the various working groups tomorrow and hearing a lot of interesting discussion. And so, with that I will turn it back over to you, Bob.

Smith, Robert (PHMSA)
Alright we'll stay there with your camera on you have one more presentation to go. Thank you very much for that overview. Let me bring up the final presentation, which is really just a few best wishes and wrapping this up for today hold on one second.

White, Sentho (PHMSA)
Alright and so I'll just jump right into slide 2 and so today, we heard from many different partners about how efforts are underway to remove challenges for safely transporting emerging fuels by pipeline and I hope that this agenda succeeded in facilitating a more common level of understanding than before joining this event and the various panels and Q&A supported and open exchange of ideas and information and dialogue that should really serve everyone moving forward and for PHMSA, you know this body of information will be reviewed and will help guide our future research activities.

And so just wanted to make a few announcements about Day 2 and Day 3 and so for Day 2 tomorrow again only registered attendees can attend the working groups that they've registered for and as Andy mentioned will also be having graduate students from our CAPP program providing presentations on their research projects. And so, you know, please return to the event meeting page where you first registered and it's also shown here on this slide. Come to see the details for the CAPP presentations that will be occurring tomorrow. And for a day 3 and you know mentioned previously but we will be reporting out all the findings from the 6 working groups and so during that time on Day 3, everyone is welcome to join so again please return to the event page where you first registered to see the agenda and the details on that.

And so again on behalf of PHMSA and the leadership team here, Mister Alan Maybury and Mister Massoud Hampton and the whole R&D Team we really thank you so much for all your assistance and your attendance and your participation. This is what really makes our research forum successful and so with that, I want to thank all of our presenters, our attendees, and moderators. The steering committee that helped with the forum and the organizers and so with that, thank you again and we trust that you're going to enjoy the rest of the event agenda these

next couple of days, so I am adjourning you all for Day One, and I wish you guys all a great evening. Thank you.

Smith, Robert (PHMSA)
Alright everybody have a great evening and we stand adjourned, so we'll see the people who are participating tomorrow, and we'll see the rest on Thursday.