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BEFORE THE

CALIFORNIA ENERGY COMMISSION

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COMMISSIONER WORKSHOP
FUGITIVE METHANE EMISSIONS IN CALIFORNIA'S NATURAL GAS SYSTEM IN SUPPORT OF THE AB 1257 REPORT

CALIFORNIA ENERGY COMMISSION FIRST FLOOR, ART ROSENFELD
HEARING ROOM
1516 NINTH STREET
SACRAMENTO, CALIFORNIA

MONDAY, June 1, 2015
9:30 A.M.

Reported by:
Kent Odell

APPEARANCES

Commissioners Present

Robert B. Weisenmiller, Chair, CEC

Staff Present

Heather Raitt
Ivin Rhyne, Moderator, Manager, Supply Analysis Office
Chris Marxen, Moderator
Mike Gravely, Deputy Division Chief, Energy Research and Development Division, CEC
Guido Franco
David Stoms, Moderator, Energy Research and Development Division

Guest Speakers

Elizabeth Scheehle, California Air Resources Board
Chuck Magee, California Public Utilities Commission
Steven Bohlen, California Department of Conservation, Division of Oil, Gas and Geothermal Resources
Timothy O'Connor, Environmental Defense Fund
Ramon Alvarez, Environmental Defense Fund
Dr. Marc Fischer, Lawrence Berkeley National Laboratory/ UC Davis
Francois Rongere, Pacific Gas & Electric Company
Deanna Haines, Southern California Gas Company and San Diego Gas & Electric

Also Present (* by WebEx)

Public Comment

*Rosa Dominguez
Allison Smith, Southern California Gas
Ryan Kinney, Clean Energy

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P R O C E E D I N G S

JUNE 1, 2015 9:34 a.m.

MS. RAITT: All right, we'll go ahead and get started. Good morning. Welcome to today's IEPR Commissioner Workshop on Fugitive Methane Emissions.

I'm Heather Raitt, the Program Manager for the IEPR. I'll go over a few housekeeping items.

The restrooms are in the atrium; a snack room is on the second floor at the top of the atrium stairs.

If there is an emergency and we need to evacuate the building, please follow staff to Roosevelt Park which is across the street diagonal to the building.

Today's workshop is being broadcast through our WebEx Conferencing System and parties should be aware that you're being recorded. We'll post the audio recording on the Energy Commission's website in a couple of days and a transcript in about a month.

Today we'll have break for an hour lunch at about 12:30. At the end of the day there will be an opportunity for public comments. We're asking parties to please limit their comments to three minutes so that the maximum number of participants will have an opportunity to speak.

For those in the room who would like to make comments, please fill out one of these blue card and give it to me. When it's your turn to speak, please come to the center podium and speak in the microphone.

For WebEx participants, you can use the chat function to tell our WebEx Coordinator that you would like to make a comment during the public comment period, and then we will either relay your comment or open your line at the appropriate time. For phone—in participants, we will open the lines after hearing from the in—person and WebEx comments.

If you haven't already please sign in at the entrance of the hearing room. Materials for the meeting are available there.

Written comments are due on June 15th. And the workshop notice explains the process for submitting comments.

And with that, I'll turn it over to Chair Weisenmiller.

CHAIRMAN WEISENMILLER: Good morning.

I'd like to thank everyone for their participation today. Obviously this is one of our more important topics as we think through the policy issues associated with natural gas is the fugitive emissions question, which certainly can have significant impacts in terms of greenhouse gas or climate change, and also may even have safety implications.

I always think of the cover of the *Science Magazine* that had the picture from space of sort of the emissions where you saw sort of a real hot spot around Four Corners, and sort of a less hot spot, but still a spot around I want to say Bakersfield.

So, again, it certainly brought home that that's an issue that we really need to focus on and certainly looking forward today to hearing about the most recent scientific research on this top, so we can get a better handle on what the policy implications are. And thanks.

MS. RAIT: Our first speaker is Chris Marxen.

MR. MARXEN: Good morning, everybody. Good morning, Mr. Chair.

In 2013, the Governor signed into law

Assembly Bill 1257. The legislation mandates the Energy Commission to produce a report to identify strategies to maximize the benefits obtained from Natural Gases and Energy Source. The first report is required to be published on November 1, 2015, and then every four years thereafter.

This workshop today is the fourth subject matter workshop that the Energy Commission has held for the report.

We have previously conducted workshops on Transportation, California's Natural Gas Infrastructure, and the Use of Natural Gas in Zero Net Energy Buildings.

We currently anticipate releasing a Draft Report to the public in late July and plan to hold a workshop on the Draft Report in late August.

Today we have assembled three panels who will present their viewpoints relating to the following topics: 1) California State Agencies Perspectives; 2) Research on Methane Emissions from the Natural Gas System; and 3) California's Ongoing Research and Potential Detection and Mitigation Efforts.

Information presented at these workshops and received during the comment period will be considered and incorporated as appropriate into the Final AB 1257 Report. With that, I'd like to turn the microphone over to Ivin Rhyne for the first panel.

MR. RHYNE: Thank you, Chris. My name is Ivin Rhyne, I'm the Manager of the Supply Analysis Office here in the Energy Commission. And it's my pleasure to head up this first set of panelists.

This first panel really brings together members of the California State Government. California is engaged on a number of issues related to understanding and curbing the methane emissions associated with Natural Gas.

This morning, I'll be giving a brief introduction to each of the speakers, we've asked the speakers to give short presentations associated with their areas of expertise, and at the end we'll have some follow-up questions both from myself, from the dais, and anyone in the public who is interested in asking questions of the members of the panel.

So with that, we'll start first with the Energy Commission and I'll introduce our first speaker, Mike Gravely. Mike Gravely is the Deputy Division Chief of the Energy Research and Development Division at the California Energy Commission. This Division manages over $150 million annually in new energy-related research and development projects.

His efforts and the efforts of his division support the energy research and development needs of the State in a variety of areas and include expanding energy efficiency and demand response, integrating renewables, evaluating new advanced generation systems, implementing the California Smart Grid, guiding energy related environmental research, of which methane emissions falls under, and assessing future energy storage needs and demonstrating energy smart sustainable communities.

Mike Gravely has a prepared presentation, so, Mike, the floor is yours.

MR. GRAVELY: Good morning. My discussion today on our research and development at the Commission here will focus in two areas, the first one is the research we're doing specifically on methane emissions and assessment and mitigation. And then the second part of this will be discussing our work in pipeline infrastructure integrity and safety.

Currently we've got some existing projects, and I'll cover these first and then I'll discuss a couple of our successful past projects and be prepared to answer any questions you may have. There are also several of the researchers are here if there are specific questions that I'm not able to answer, then I'll be glad to bring them up to the mic for them to answer any questions that may come up.

In the area of methane emissions, the four projects that we've talked about in general, and I wanted to cover the overall assessment, one project is looking at the quantification of the residential area and making measurements to determine if the residential peaks are in line with the expectations or higher than expected areas, and what areas they would be -- talking about natural gas use in the home for heating and for cooking and other opportunities for natural gas, and determining if there is a substantial amount of leakage that needs to be addressed in that area.

The next area is improvements in leak

detection and this is a case where they're working with the utilities to determine if there are better ways to detect natural gas leak of the infrastructure, and also to determine ways to identify areas where this will be the best for mitigation and determine how to do that. This would be developing analytical areas and this is one where they've actually been looking at taking some measurements and then determining from those measurements where the best areas are.

Evaluation of Opportunities to Mitigate Fugitive Methane Emissions from the California Natural Gas System. In this case here, it's looking at the whole system, in general, across the industry, trying to find methodologies to reduce methane emissions and also to determine different mitigation techniques and compare the cost of the mitigation to the value of the mitigation technique to determine which ones are most cost-effective for the utility.

And this last one here is on a Top-down quantification where they're looking at taking air measurements and land measurements and trying to figure out methodologies to assess where the leakages are coming out of buildings, coming out of pipes, and also to determine the concentration, and based on that to develop some assessment of where we are and also come up with various areas for mitigation.

A couple of major successes that we've completed in the past or are wrapping up right now, this case here, there is some work being done by the Lawrence Berkeley National Lab where they took some measurements from towers and actually measured the intensity of the methane in the air to determine if they could use those measurements to actually take over time, reductions; as we address our AB 32 goals, one of the elements is determining if we're getting the savings that we're expecting to get and are we actually reducing those. So this one is where they actually took two different towers, took the readings and developed models to see if they were able to in fact measure that and estimate that.

In the area of natural gas system, this is a case where they've looked at the different areas throughout the state and determined what methodologies were available in the distribution system, as well as production and processing of natural gas, the storage of natural gas, and transmission of natural gas, looking for areas for potential leakages and looking for areas for mitigation opportunities.

The final one we have here is talking about the opportunity where we're doing some actual airborne measurements here, so they're doing measurements both from aircraft, as well as ground systems, and they're measuring the intensity of the methane in the air and they're able to separate the intensity from the technology that they're using, and also help them to understand if they can determine where the leakage is coming from. The goal here would be to be able to identify leaks from a non-intrusive system and also to be able to determine where it's coming from and go back and work on reducing those emissions.

The next area in Research and Development is in Pipeline Safety and Infrastructure and Integrity. Here are some of the ongoing projects here looking at monitoring the system to determine where the leaks are and determining how to mitigate those potential leaks. There's technologies in this area, we're looking at two types of technologies, one would be technology where you would run sensors through the pipes and they would look for integrity, they would look for cracks, they would look for wells and joints, and the other one is you're trying to find opportunities to determine leaks and determine the integrity of the system by not having to be intrusive, in other words by using sensors, by using computer systems to track the movement of the gas through the lines, and to do that in a manner that you would be able to predict when an unusual amount of gas was leaking in one area to give you some kind of indication that there was an area that needed to be researched in more detail, or looked into closer.

Here are a couple examples of work that we've done. This shows you one of the types of sensors that goes through the pipeline on the top picture, and on the bottom picture it shows you the NIMS technology that's used for measuring, again, some of this is done inside the pipe, some of this is done outside, it depends on whether you're trying to look at things as for actual pipe integrity. Obviously, when you get inside the pipe, then that requires more intrusion into the system than if you can develop a sensor system that can do this outside the pipeline and without having to shut down the pipe and do these maintenance activities.

This is another technology we looked at, so we've been looking at different ones to develop not only pipeline integrity, to be able to look for corrosion, to be able to look for cracks in the pipe, to be able to look for leaks, this is another technology, another vendor product to go through the pipelines checking for integrity and being able to determine the potential for leaks in the future.

The next one hear talks about where a computer system, where they're looking at monitoring the natural gas system, and looking at the flow through the system to determine if the flow has been disrupted, determine if there is an area there. It also allows them to look at intrusion, so if someone is digging and begins to impact the pipe, and they begin to see changes, they'll notice it right away and can maybe, if they haven't been determined, they can go make a correction enacted before it becomes more damaging from there.

So again, if there are any questions from the panel?

CHAIRMAN WEISENMILLER: Yeah, let's start with I guess the basic question on methane emissions, a lot of our work seems to be focused on pipelines, and I was trying to understand our ability to differentiate between gas from pipes, natural gas, versus emissions from Agriculture, you know, things like raw sewage, composting. So where are we at this point in terms of the census between the two? I don't know if Guido --

MR. GRAVELY: Dr. Guido will answer here for us. But in general, they're able to use methodologies to determine the difference and specify it, but I'll give more specific answers from Guido here.

MR. FRANCO: Thank you, Mike. I don't have a doctor's degree, but it looks like it. Okay, yeah, so the researches are using tracers like for example ethane --

CHAIRMAN WEISENMILLER: Okay.

MR. FRANCO: -- that are associated with methane types of releases from the natural gas system, but it is not present in -- or almost no presence from biogenic sources like landfills or other sources. And also, they are using oil traces opportunities like volatile organic compounds, you know, that could differentiate from where the methane emissions are coming from.

CHAIRMAN WEISENMILLER: Okay and in terms of looking at our overall inventory, what's your sense of the breakdown of fugitive emissions between, you know, this sort of biogenic versus the natural gas pipeline system?

MR. FRANCO: Okay, the ARB inventory suggests that, at least for the San Joaquin Valley, that the vast majority of emissions are coming from landfills, dairy farms, and in general the agricultural sector. A relatively small amount is coming from the natural gas system, but a relative number depends on the eye of the person looking at the data. This afternoon, Dr. Marc Fischer will give a presentation about the latest results.

CHAIRMAN WEISENMILLER: Okay, do you have a sense of natural seepage? What that level might be?

MR. FRANCO: Natural seepage is mostly happening at least in Los Angeles, in the Los Angeles area, and there have been attempts to estimate the natural emissions and to be able to estimate the emissions from the natural gas system because when you are measuring concentrations you cannot distinguish between natural seepage and the methane coming from the natural gas, but there have been different studies trying to estimate emissions coming from natural seepage.

CHAIRMAN WEISENMILLER: Do you have a sense of the seasonal variation on gas, on emissions, particularly on the pipeline system?

MR. FRANCO: We don’t have information, but one of the things that Marc Fisher is going to say is that emissions are sporadic, there is not a steady level of emissions, so spot measurements may not do the job because we need methane emissions on an annual basis, and he will talk about the fact that in some cases he sees high emissions, on other days his measurements suggest relatively low emissions. So there’s a need for more continuous type of measurements to get at an annual level estimation of emissions.

CHAIRMAN WEISENMILLER: Yeah, I mean obviously in terms of operating the gas system, you can pack gas in at certain times, you know, if you expect surges in demand, or again you’ve got that variation of packing and also in terms of demand, you could have periods where there's lots of gas flowing out or other periods like the summer where there was presumably relatively little.

MR. FRANCO: Yeah, so our research is trying to explain or trying to find reasons for these high emissions, but I think we're not there yet. Like for example, in underground storage facilities the emissions are not constant. And we're trying to figure out, you know, under what circumstances we see relatively high emissions.

CHAIRMAN WEINSENMILLER: And some of the research you and I have talked about also talks about the Fat tail distribution that we might have, say, 80,000 oil and gas wells in California, but that there's a limited number of those that are relatively high emitting. So, as we go through the various studies, how are we sort of differentiating between those fat tails?

MR. FRANCO: Yeah, so the same results apply for the entire natural gas system and we're seeing the same behavior; even when Fullerton State University measured emissions from other compound levels, like for example valves or phalanges, and the same thing. And the problem is that there are no easy ways to determine a priori when a unit or a system is going to be a high emitter, a super emitter. So we need to start developing methodologies to identify super-emitters. And there are efforts on the way, you know, to do that including I think some presentations the EDF is going to provide today, but there are other groups doing similar things and we're involved in that type of work.

CHAIRMAN WEISENMILLER: Okay, last question is, similarly in terms of homogeneity, one of the things we're going to look at is residential emissions and sort of those of us in the Energy Efficiency Space, you know, going back to Socolow's pioneering work at Princeton, always sort of realized that you could have a subdivision of houses and, depending upon the construction practices, you'd have much different energy efficiency or energy usage going across that subdivision. So I'm trying to understand statistically, you know, how are we dealing with the potential variation in households as we try to track what their contribution is.

MR. FRANCO: Yeah. So Barry Fischer and

his group have conducted some very preliminary measurements, just about 10 homes, and it was mostly to develop the methodology to estimate emissions from homes. But there is new work that started just a few months ago where he's going to be measuring about 100 homes in California; that may not be enough, but the idea is to start this work and find out what else is needed. Again, he will be presenting some results this afternoon suggesting that, yeah, we have leaks from our homes. And we also have planned work looking at all the facilities downstream of the meters like buildings, industry, homes, I mean, yeah, other end users.

CHAIRMAN WEISENMILLER: Okay, thanks. Let's go on to any other questions for Mike or Guido.

MR. RHYNE: Right. None for me. So thank you, Mike; thank you, Guido. We'll set up for the next presentation here.

Our next presenter is Elizabeth Scheehle from the California Air Resources Board. Elizabeth is a Branch Chief for the Oil and Gas and Greenhouse Gas Mitigation Branch at the Air Resources Board. She's been at the Air Board for eight years with experience in oil and gas, carbon capture and sequestration, cap-and-trade, and field measurements. In her current position, she oversees regulatory and analytical initiatives related to the oil and gas sector.

Before joining the Air Board, Elizabeth was a Senior Analyst in U.S. EPA's Climate Change Division. She holds Master's Degrees in Public Health from John Hopkins University and a Master's in Public Policy from Harvard University's Kennedy School of Government, and an Undergraduate Degree in Earth and Atmospheric Sciences from Georgia Institute of Technology. Elizabeth?

MS. SCHEEHLE: Thanks. And thank you for the opportunity to talk about what ARB is doing on oil and gas, on methane emissions from oil and gas. This is an important part of our overall goals to reduce back to 1990 levels by 2020 and the recently announced Governor's goal of reaching 40 percent by 2030.

I'll walk through why we feel methane emissions from the sector are important, what can be done, what ARB is doing, what research we're conducting, and what's our plan going forward.

So supporting our greenhouse gas goals, we've recently released a draft concept paper and held a workshop last week on our Short Lived Climate Pollutant Strategy. The strategy covers methane, as well as black carbon and fluorinated gases, and the plan lays out a goal for reduction in methane emissions of 20 percent by 2020 and 40 percent by 2030. The oil and gas sector is one important part of this strategy.

In addition, we're looking at methane emissions from natural gas infrastructure as part of our larger technology assessment for vehicles and fuels. The emissions from the natural gas infrastructure is often called "methane leakage," but that actually includes a lot more than that, it's leakage, it's intentional venting, and oftentimes also includes combustion. That plays a role in how natural gas and electricity and other things compare in terms of vehicles and fuel choices. But the methane leakage is just one component. The use of renewables, tailpipe emissions are also big components in that assessment.

Related, the Low Carbon Fuel Standard calculates lifecycle carbon intensities for all fuels, including conventional and renewable natural gas. Methane leakage is a component of that assessment.

And I want to also mention that the Governor's goal for cleaner home heating fuels and reducing methane emissions from the natural gas sector is one potential mitigation measure that would reduce greenhouse gas emissions from that sector.

To put the emissions in context, I'm showing the results of our Draft 2013 California Inventory. As you can see, natural gas and oil make up 15 percent of the methane emissions in 2013. That's from the entire sector with nine percent coming from the pipeline side and six percent from oil and gas production. And production includes processing, as well. And when I talk about pipelines, that nine percent is not just the pipelines themselves, but also other infrastructure such as the meter and regulating stations and the compressor stations.

The improvement to this inventory is from some work we did several years ago that was a very in-depth survey of the industry in the transmission distribution and production side to improve our inventory on that side, so it has actually increased since our last inventory.

And then that's the top, that's the middle graph that you'll see. The bottom two, which are a little bit more challenging to see, I didn't realize they would come out that small, but that compares methane in general to the other gases, so if you use the 100-year global warming potential, the methane emissions are about eight percent of total greenhouse gas emissions.

Given the short-lived nature of the emissions, looking at the 20-year global warming potential is also interesting. This is shown in the pie chart that's labeled 2013-B and those methane emissions rise to 17 percent of the greenhouse gas emissions when you look at it that way.

CHAIRMAN WEISENMILLER: So is that by weight, by molecule? What's your metric?

MS. SCHEEHLE: That's the total, so it's million metric tons of CO_2E is what we're looking at, and it's just using for the 100-year it's 25, and I believe the 20-year is 83, something around there, so that's why you see the difference.

I also wanted to show the national

emissions and leakage numbers because this is important, especially when we're thinking about where our natural gas comes from. So one reason is we get an overwhelming amount of our natural gas from out of state, and we get a majority of our oil from out of state, as well. The gas is often found along with oil, and so that's why I've included the petroleum numbers here, as well, because a lot of the associated gas, what they call associated gas, is actually accounted for in that pie chart.

And there are many ways to apportion those emissions. These are the U.S. EPA numbers from their most recent inventory. And, like I said, they apportion the associated gas and petroleum.

The leakage estimates are determined by taking these U.S. EPA numbers, generally, or other numbers, other emissions numbers, and dividing by some sort of metric, often through-put. When we've looked at the studies that are out there, a recent meta-analysis from last year and other studies, generally the leakage rates fall between one and three percent, but there are some outliers for that.

In the Low Carbon Fuel Standard, we've used an estimate of 1.15 and this value is used in a key model that, as it says there, is the GREET model and it's based on the U.S. EPA numbers adjusted for combustion, which is found elsewhere in the model, and discounted for distribution since the fueling stations are oftentimes a little bit more upstream of the system.

One thing that is of note is that this leakage number is of great interest right now. There's a lot of studies going on, recently completed, and reconciling the top down, the atmospheric studies that we've talked about some, and the Bottom-up more equipment-based studies that have been coming out, they will be important in the coming years and we're going to be closely following those studies and incorporating them where appropriate in our analysis.

So now that I've covered what the emissions are, I wanted to touch on what could be done to reduce those emissions. This is not an ARB chart, this is more just illustrative, it comes from an ICF Report, but it's just more illustrative of what can be done, that there are cost-effective measures out there for the natural gas sector. And this shows the green are the ones that are cost savings, and the width is how much you can get from that. So I just wanted to show that there are cost-savings measures out there and we are actually in some ongoing rulemakings that I'll talk about next, that look at both how much it costs and what some of the savings and how much you can reduce from various options.

So to move into what we're actually doing right now, we're covering sort of the whole sector. I put the scheme of the infrastructure on the right. And first, we're in the middle of a rulemaking right now on the production processing and storage sector and that actually also includes the compressor stations along transmission lines because they include a lot of the same components when you're talking about obviously the compressors themselves and other things like pneumatics and tanks that may be there, as well. So that includes that first part, the production processing, and a little bit of the natural gas transmission storage for the storage and the compressor station portion of it.

We have a draft proposal and that includes mitigation for compressors, pneumatic devices, storage tanks, recirculation tanks related to well stimulation, and leak detection and repair, as well as the reporting component on liquids unloading.

And I wanted to mention leak detection and repair and get to your earlier question, Chair Weisenmiller, about super-emitters, and this is one place where we think that fat tail and having a leak detection repair program is very important in order to address some of those and get to some of those super-emitter fat tail issues.

We're also working closely, and I know Chuck will be talking about this in a minute, so I'll just touch on we're working with the CPUC on a measure on transmission distribution pipelines, as well. We're just getting in the data from the utilities and we'll be working with the PUC on mitigation options.

Between these two Regulations, the State is addressing emissions from the various infrastructure sectors, but we do think National actions are important since we get the majority of our oil and gas from out of state.

As this map shows, actually taken from a CEC document, only approximately 10 percent of our natural gas comes from within the state. We get the rest from a variety of mid and western states and Canadian production fields. The practices in emissions from outside of California are also important to reducing emissions related to the gas that we use within the state.

CHAIRMAN WEISENMILLER: Actually, I meant to ask you, and that's a great chart for the question, so flipping back, do we have a sense of the variation in emissions across from, say, Permian to Alberta? Obviously some of the, well, our relationship with Texas and Canada go back to the '50s, you know, and it was more in the '90s that we started bringing in lots of Rocky Mountain Basin gas, certainly California production was from the '30s. So, again, the sort of technologies are different. Do we have a sense of which of these are the most problematic sources?

MS. SCHEEHLE: I think we're getting into right now the differences between those basins, and it's a little challenging because there's a lot of studies, and so you have to dig through all of those different studies and see what the actual differences are. If you look at the EPA methodology, there's some variation they have, some very large regional distinctions, but their regions are fairly large. But there are some differences between what you'll see in Texas than, say, California which is a lot of what it is in the Western Region. But that's something that we're going to be looking into as we go forward in the process and try and refine our estimation.

So I also just wanted to touch on some general thoughts as ARB has started to look into methane emissions and what's often called "methane leakage." As I mentioned, it's really the emissions to the atmosphere that we consider important. Leakage is one way to look at this, it's not a perfect way, it's just one measure related to the through-put of the system. And the emissions and the opportunity to reduce these emissions is what we feel are the important part. But if you look at leakage and you use that as a metric, it's important that you compare apples to apples because there's a lot of different ways to look at that. What you include, what you use for through-put, and different things like that, there are also multiple ways to apportion the emissions. As you mentioned, super-emitters have been noted a lot more in recent studies and that's something we feel is important. It's the term that's used for a small number of sources accounting for a large percentage of the emissions.

Recent studies in oil and gas sector, and actually other sectors, as well, have found this fat tail to be an issue and we consider that this is important to consider how to find these sources to reduce the leakage, and that's one reason we're looking at the leak detection and repair programs through our regulatory process.

Studies are ongoing using top down, the atmospheric measurements, and Bottom-up methods. As I mentioned, a recent meta-analysis was done last year that concludes that the EPA number is under-estimated, but some studies that have been completed since then have varied results suggesting that certain sources are actually over-estimated. And there are also additional studies underway including an ARB study where we're looking at pipeline leakage. So given the discrepancies and evolving data, a really deep dive into this is necessary over the coming years.

And I wanted to touch really quickly on some of the research that we're doing, we have a lot of research ongoing. For oil and gas sector specifically, I mentioned an in-depth survey we conducted a few years ago that includes equipment and practices in California. We're currently in the middle of a few contracts, one is focused on above and below ground measurements of distribution pipeline leaks with measurements throughout the state, both in Southern and Northern California.

We're also finishing up two contracts on the production side. One is comparing leak detection repair equipment with resulting comparison of emission estimates, and then another is looking at well stimulation events.

The agency has several research programs that look at methane emissions as a whole. We have a network of towers throughout the state equipped with methane detectors, and that's the map over on the left-hand side that shows both our towers and other stations that are out there, and other stations where we're working with LBNL, as well.

In addition, we have middle monitoring platforms that look at -- that enable sort of the source level estimations. They have trace release methods, flux chamber methods, so we have a lot of research ongoing.

We also work with other entities on projects. Those include things like Mega-Cities project and recent flyover campaigns in the Central Valley of California. And that work included flights over large oil and gas fields and the results from that will be hopefully available later this year. These campaigns provide information helpful to informing our overall understanding and may help identify future areas for study or action.

So just to finish up, ARB is addressing methane emissions from the oil and gas sector as a whole. We plan to go to the Board for the production processing and storage sector later this year. And we're working closely with the PUC on the transmission and distribution side.

We will continue the public process on

lifecycle methane emissions from oil and gas with additional opportunities for stakeholder input. We will also encourage national level action on methane such as those outlined in the current Administration’s goal to reduce emissions from the oil and gas sector by 40 percent.

This is an important sector for reaching both our short and long term goals on greenhouse gas emissions and we will continue to look at this closely. So thank you.

CHAIRMAN WEISENMILLER: Thank you. Do you have a sense of the relative emissions from what I’ll say conventional gas production versus, say, coal seam versus fracking?

MS. SCHEEHLE: That’s a good question. Hydraulic fracturing and different types of oil stimulation, it depends on where it occurs if the emissions are higher or not, and a lot of it depends on what sort of infrastructure they have in place, so in areas where it’s newer, there tends to be more emissions because they don’t have as much infrastructure to deal with the gas that’s coming out. But it’s variable.

CHAIRMAN WEISENMILLER: Okay. And I would just note, one of the more controversial items in the first Brown Administration was the notion for California to have its own satellite for remote sensing. Obviously we didn't succeed.

MS. SCHEEHLE: No, but hopefully, I mean, through all of the work that we're doing with some of the plane measurements and the towers, I think we're getting a better sense of what's going on.

CHAIRMAN WEISENMILLER: That's good. In terms of what would you say is the major focus for trying to reduce uncertainty, you know, to narrow the uncertainties here? What should we do?

MS. SCHEEHLE: That's a good question. I think it's just a combination of continuing what we have. I think part of the difficulty is there's a lot of different sources and, I mean, we're getting into the residential sector which we're just learning about what's happening after that. So I'm not sure if we've identified this is the best way to go to figure out what the uncertainty is, but the combination of using the Bottom-up and the top down, because they both have their different uncertainties, you take the Top-down and you have to figure out how to take concentrations and apportion them to a source which can be highly uncertain; with Bottom-up estimates obviously you're taking every single piece of equipment and there could be some of these super-emitters and how to deal with that, so I think it's taking those and being able to work together with them and find out why there may be any discrepancies and resolve those.

CHAIRMAN WEISENMILLER: That's great. I think part of it is, and obviously we'll ask for written comments eventually, and certainly one of the areas I'd like people in their comments to think about is what are the key areas, key uncertainties, and what we should be doing to sort of narrow those uncertainties and, obviously, mitigate things. Okay, thanks.

MR. RHYNE: Okay, thank you. Our next presenter comes from the California Public Utilities Commission. Chuck Magee is a Senior Utilities Engineer with the California Public Utilities Commission. He has worked at the CPUC for over 14 years. Mr. McGee was one of the first members of the PUC Risk Assessment Unit, which was created in October of 2011 after the San Bruno explosion. Since that time, he has worked on projects to identify gas system hazards and evaluate utility risk assessment programs. Chuck?

MR. MAGEE: Good morning. I’m here today to discuss SB 1371 which is the Natural Gas Leakage Abatement Bill that was approved by the Governor on September 21st of 2014.

It applies to CPUC regulated intrastate transmission, distribution and storage facilities. It requires the CPUC to “minimize” leaks as a hazard to be mitigated” and to reduce emissions of natural gas “to the maximum extent possible” to advance goals of greenhouse gas emissions. I was doing a little fact checking last night and the actual word is “feasible”, not “possible” as it is stated there.

It directs the CPUC to “establish and require the use of best practices for leak surveys, patrols, leak survey technology, leak prevention, and leak reduction. Again, the word “detection” is incorrect according to the bill, it’s leak “reduction.”

It requires gas corporations to file reports about natural gas leaks and leak management practices and "estimates of gas lost due to leaks."

It required a baseline report which we determined the due date for that in our proceeding, we determined would be May 15th of this year and those reports were filed.

And it requires an annual update. And so every May 15th in the coming years, the utilities will be filing updates on incremental changes to the gas leak reduction programs.

And the bill requires us to confer with the California Air Resources Board and open a proceeding to adopt rules by January 15th, 2015, which we did. And that's Rulemaking 15-01-008.

The bill also requires us to identify best practices and so as a result we wrote a report called "Survey of Natural Gas Leakage Abatement - Best Practices" report and it was issued for comment on March 18th, 2015. In the bill, we mention that Methane emissions are described as a potent greenhouse gas with impacts greater than 20 times carbon dioxide, and that number is probably a minimum number depending upon which research paper you read, you see numbers higher than that.

We also identified the major sources of leaks. Much of the report was based on two other reports that we found, one was from ICF International which was issued in March 2014, and the other report is the U.S. EPA Natural Gas STAR program, which identifies a lot of best practices and also lists payback times for modifying equipment or doing capital improvements. So that was a big help.

We proposed in the report that, for purposes of SB 1371 greenhouse gas reductions, all leaks should be considered hazardous to people, property, or the environment. Up to now, leaks have been considered hazardous based on dangers to people and property, so adding the environment to it is a new change in the definition.

And it recommends that the best practice would be to repair all leaks immediately as they are found, but we recognize that might not be practical or cost-effective. For small utilities, they frequently do that, repair leaks as they are found, but the large utilities have such a large customer area that it may not be practical to do that.

Other best practices were compiled on the Report Appendix spreadsheet. I'd like to mention that the report itself is a summary of what I found when I reviewed all these best practices and reviewed the ICF Report and the Gas STAR Program. The actual bulk of the work, though, can be found in the Appendix spreadsheet where we identified as many best practices as possible from Europe, Canada, and North America.

So to identify best practices for people who are looking for tips on best practices, I would suggest going to the spreadsheet shown in the Appendix; there's a lot of links there to the Web, manufacturers, cutting edge technology, and I think it's a good resource to try to identify new best practices or best practices you might not have thought of before.

The CPUC held a workshop on April 6th and in that workshop, the participants reviewed the staff report on best practices for methane leak abatement. The Air Resources Board provided an update on their proceedings, as Elizabeth just mentioned. We had an open discussion of policy aspects, we discussed what the definition of leaks should be. Currently, the definition of leaks is a safety-related definition. And we also discussed how cost-effective feasible best practices, how those can be balanced.

There were presentations on technologies and tools for improved leak surveys and mitigation and we'll hear more about that this afternoon.

And there was interest and initiative to form a Technologies/Tools Working Group. And at the end of the workshop people were already getting together to discuss that.

Specific policy issues discussed in the workshop, we discussed the intent of SB 1371. Some parties questioned whether it's applicable to operation and maintenance emissions, does it apply to all emissions and leaks or were there any exceptions or exemptions? And I didn't see any exemptions in the bill, but there was some disagreement about that.

We discussed new methane emission limits and those are not clear yet, we're working with ARB on how to actually decide what methane emissions or limits should be, if any.

And we discussed the new leak rating system. Currently the leak rating system goes

Grade 1, 2 and 3, with Grade 1 being the immediate dangers to people and property, which have to be addressed right away, permanently repaired, I believe it's within 15 months, but they have to be stopped right away.

And then there's Grade 2 and Grade 3. Grade 3 are considered not hazardous to persons and property and up until now they've been allowed to leak indefinitely, provided they were monitored to make sure they weren't getting worse. But in rural areas where it's no danger to people or property, they were allowed to just leak. And that might be where we find some of the super-emitters that we've been talking about today.

Specific technical issues discussed in the workshop, we discussed the technologies to find leaks, there's a lot of cutting edge R&D instruments and technology out there, more coming on all the time, technologies to quantify the amount of methane leaked from individual leaks. Underground leaks especially are problematic since the gas can migrate and you've got to trap it all to know how much is actually being emitted from underground. And we also discussed technologies to quantify system leak rates.

Some of the issues for the Commission to consider now: Whether to revise the definition of gas “leak;” how to balance “technologically feasible, cost effective, and use best practices;” whether specific best practices should be required; whether to revise the leak rating system; what target emissions level should be required; what leak repair time limits should be required; whether to revise General Order 112 which currently addresses safety issues only, so the question is whether we should revise that to also include best practices or limits for purposes of protecting the environment.

And also, we are looking at what training programs, what workforce levels, capital improvement programs, and potential incentives are needed for gas corporations to reduce leaks.

The next steps: the first step was completed on May 15th, we received the reports, the required Methane Leak and Emissions Reports, from the respondents; Methane Leak and Emissions Reports now have to be analyzed by the CPUC and the ARB, and the completion date of that is to be determined since we only got them about a week ago, or two weeks ago. And the reports go to both the CPUC and ARB.

And so the next step is on June 8th, 2015, there is a prehearing conference to set the scope of the proceeding and the tentative schedule.

And my name and contact information are on the last slide if you have any questions, would like to contact me, or my supervisor, Arthur O'Donnell, and his contact information is there also. Thank you.

CHAIRMAN WEISENMILLER: Great. A few follow-up questions. One of them is just trying to understand. So you've got this proceeding, it was set in place, the framework. Now my guess is that basically in the future general rate cases will be the forum where, I guess has been the case in the past, so I assume going forward, where the Commission has to come to grips with what's the cost and what are the benefits, you know, like in the last PG&E General Rate case it was a big issue of what should be the frequency of basically the surveys, you know, for leak detection. Is it sort of a three-year, five-year, two-year, you know, and the shorter times require more money. And so somehow the Commission had to come to grips with that, and I think one of the PG&E proposals was that for sensitive infrastructure you might do a more frequently than general. So if you're in areas of hospitals or stadiums, or something, you might do the leak detections on an annual basis instead of an every three-year basis. I forgot how that played out, but typically in General Rate cases PG&E asks for a certain amount of money to do it a certain frequency, most Interveners wanted to give them less money which meant lower frequency. So, I mean, how do you go from this generic proceeding to the real issue on dollars and cents, and what's the tradeoff in going forward for the PUC?

MR. MAGEE: That's a good question, it's going to take time to sort it all out. The proceeding is going to be -- we try to complete our proceedings 18 months from the prehearing conference. Our Energy Division is going to be involved with us trying to figure out the answers to those questions. I do know that, I guess it's pretty obvious, that the more leak surveys you do the greater percentage of leaks you find and that actual figure was, I believe it was in the ICF Report, the State of Colorado had actual figures for how much gas reduction you could find with varying frequencies of leak detection surveys. So, yeah, that's something that will have to be sorted out.

CHAIRMAN WEISENMILLER: And the other question was, there is some of the plastic pipe which is defective; what's the current policy in terms of how quickly to replace that? And is that related to leakage or not?

MR. MAGEE: The exact relation to leakage, I think it's been more of a safety issue than anything else. The utilities are working on replacing aldyl-A pipe, there's a few other types of pipe and fittings that need to be replaced and it's an ongoing process. Some of the difficulty, I believe, is knowing where all of it is located exactly. And so one of our team members, Steve Haine, did an aldyl-A report that discussed some of those issues, but exact relationship of plastic pipe to methane leaks as far as the environment is concerned, I don't know the relationship of that. From just a cursory review of some of the numbers that we've gotten back from the utilities, I'd say the biggest amount of methane leaking are from these Grade 3 leaks, whatever material they are. And we haven't been able to -- in the short time since we got the report, we haven't been able to come up with any statistics as far as what materials are leaking the most. We did get the materials in the reports, now it's a matter of sorting through it. But I'd say most of the methane leaks from pipelines, that Grade 3 variety which may be out in rural areas and that we have to go after those first.

CHAIRMAN WEISENMILLER: Well, certainly looking at Line 300 and 400, I mean, they're very old pipe, I guess the oldest pipe in California is probably Stan-Pac. And certainly 400, when 401 was put in, there were some degree of upgrades associated with that and there was sort of an emergency effort on Stan-Pac to deal with leakage from that. But 300 is very very old pipe. I remember even in the '80s there was speculation that unless there was lots of investment in it, that there would be issues there. But again, I think the issue that's going to be important is obviously the Commission has in place sort of a safety policy now and sort of going forward, again, having a general policy but then trying to frame the issues in a rate case so those people try to do the tradeoff between cost and benefits from a risk assessment, it’s done as scientifically as possible. You know, what can we do to minimize, for the most bucks, flipside, I mean, going back to your prior chart on cost-effectiveness, what’s are the most cost-effective things we can do to reduce emissions on our systems, which could be locations or types of stuff, and how to do that quickly where there are safety issues.

MR. MAGEE: Yeah. For emissions purposes, I think that emissions and safety are really two different issues.

CHAIRMAN WEISENMILLER: Okay.

MR. MAGEE: From what I see, we may be able to make a lot of progress when we start looking through those reports and, as I said, I saw a lot of what appeared to be large emitting Grade 3 leaks which obviously aren’t safety-related, but if we can clean those up that would probably be the biggest bang for the buck in the beginning. So I would anticipate -- at this point, again, we've only had the data for two weeks, but I would anticipate that we could cut down on a large amount of methane emissions in the beginning and then gradually taper off as the smaller leaks we figure out what to do with.

CHAIRMAN WEISENMILLER: Okay. And last question is just part of Mike Gravely's presentation was to go through some of the research in the areas of safety in terms of new technologies, so certainly that would be an area of PUC feedback on the research we've done so far and also the criteria for any subsequent research, the sorts of new technology that would, again, provide the most benefit would be useful.

MR. MAGEE: Yeah, again, there's a lot of new technology coming on and the people this afternoon can tell you probably more about it because they work with it all the time. I just looked at one the other day that PG&E is using, laser cameras that can do detailed 3D maps of pipe surfaces, or anything else you want to take a 3D image of, and use it to analyze the anomalies in the pipe walls. And there's smart pigs, again, there's a lot on that Appendix spreadsheet that was in the report, all times of inline tools that can go through and detect small leaks, so there's a tremendous amount of technology out there and more coming.

CHAIRMAN WEISENMILLER: Great, thank you.

MR. RHYNE: All right, thank you. Our last presenter comes from the Department of Oil, Gas and Geothermal Resources. Dr. Steve Bohlen was appointed by Governor Brown on June 2nd of 2014 as State Oil and Gas Supervisor and head of the Division of Oil, Gas and Geothermal Resources.

Dr. Bohlen has devoted much of his career using scientific evidence to inform policy development and multiple levels of Federal and State Government. Prior to joining DOGGR, Bohlen served science and society as a prominent researcher, professor and senior manager of national and international research programs in the geosciences.

Most recently, Dr. Bohlen was the Program Director for Nuclear and Domestic Security from 2013 to 2014, and previously the Deputy Program Director for Energy Security from 2011 to 2013 at Lawrence Livermore National Laboratory. Dr. Bohlen?

DR. BOHLEN: Thank you very much. Good morning. I was asked to give some perspective as to what actually is going on in the state with regard to production of oil and natural gas and to talk a little bit about what might happen with respect to well stimulation in the state and how it may be reflected in the issue at hand.

I will say at the outset that I learned long ago that Yogi Berra had it right, that predictions are difficult, especially about the future.

Just a quick reminder, I'll provide some context as to how California plays in the larger energy market and then talk specifically about some issues around methane leaking and the industry itself.

California is the third largest producer of oil in the country. We just nose out Alaska essentially as Trudeau Bay starts to take over really as a gas producer rather than an oil producer. This slide shows, it's hard to read but the largest oil producer in the country is Texas, you can see the sharp upturn in the red line over the last 15 years, and then farther down you can see the other upturn line is North

Dakota. Those are both a result of well stimulation technologies that's really changed the energy picture in the country.

California is the third line down, the purplish line, and you'll see that there's no increase as of yet as a result of well stimulation technologies in oil production.

California was the Saudi Arabia of the world during the '20s, '30s and '40s; obviously since the late '80s the production in the state has been declining monotonically and it's not clear where the production will go given the advances in technology. You can see that the state had a rather different view of its environmental interest in the late '20s, that's a view on the left of downtown Los Angeles, and on the right is South Belridge, probably one of the most densely drilled oil fields in the world.

The gas in California is actually produced from oil, as Elizabeth has already talked about. The northern part of the state has gas fields, those are all the red dots, but those geologic formations have to do with gravel that has accumulated in river meanders and so the deposits of dry gas in the northern part of the state are relatively small in comparison with the larger amounts of gas that are produced along with oil in the large oil fields in the southern part of the state.

So as Elizabeth has already mentioned, California is very much an also ran in terms of its production of natural gas. California is the red line at the bottom of the graph and you can see there's a number of other states including Alaska, Arkansas and so forth, Louisiana and so forth, that are well ahead of the state, hence we only produce about 10 percent of the gas that we use.

A chunk of our gas, though, actually goes to create steam for steaming of the heavy oils that make up some of the California oil supply. It's important to note that California is a big energy user, we import twice the amount of oil we produce on a per day basis and 95 percent of that goes for transportation fuel. So changing people's driving habits which the Governor says is never going to happen, or electrifying the transportation sector is really important.

All roads it seems lead to hydraulic well stimulation and fracking these days, including every earthquake in the state; the first question I get is "was it caused by hydraulic fracturing?" And fortunately in a previous part of my career I worked for and led science at the U.S. Geological Survey, so I look up on the website to look for the moment tensor and the depth of the earthquakes and I can answer that question very quickly.

So fortunately we have Senate Bill 4, which now requires that we have a great deal of information reported to the state on well stimulation activities. The upper set of numbers talks about the notices that we have received. Essentially since data started to be required to be reported to the state January 1st of 2014, we've received a little over 1,200 well stimulation notices. Most of the well stimulation in the state goes on in one county, Kern County, and that's about 99.5 percent or 99.6 percent of the well stimulation activity and most well stimulation activity is related to the production of a certain kind of formation, diatomite, which is a formation -- it's the old remains of an ocean in the inner parts of the state filled with diatoms and the formations have a large amount of porosity, but very little permeability, so actually getting the pores to connect is critical. And that's for oil production and not for gas production.

So hydraulic fracturing is a steady component of the oil production activity in the state and it's all going on at the moment really in just a few oil fields on the west side of Kern County. And this map shows you just what I said, so let's move on.

I will take a mention about how much water is used. Well stimulation in the State of California is quite different from the well stimulation that you've read about in North Dakota or the Eagle Ford formation in Texas, or the Marcellus Shale. Last year the state used about 300 acre feet of water for all the well stimulations; that compares with 14 million acre feet of water that were drawn from aquifers during the course of the year for all beneficial uses. So we do not use a large amount of water. That's just an aside because that's usually the first question that everybody asks me.

So what could happen though? The issue around well stimulation as we know has been game changer in Pennsylvania that’s moved to be the third largest producer of natural gas in the country, and obviously in terms of oil production in Texas and North Dakota. And the real question around where does California go in terms of oil and, to a lesser degree, gas, is around the Monterey formation which you can see in green. It’s going to be an oil producer, it’s not going to be a gas producer like the Marcellus Shale, and there’s a large number of reasons why this formation is not already a producer of oil. Unlike the formations, the Bakken formation in North Dakota, the Marcellus in Pennsylvania, you can drill a horizontal lateral in those formations two miles out and still be within a few meters of elevation change. That’s not true in California. The other problem is that in California there are chert layers, also the remnants of diatoms that have been compressed from the inland sea, and it turns out that when you try to fracture formation containing layers of chert, that chert as a rock is very fracture tough, and so what it actually does is it causes the fractures that are propagating into the chert to deflect along to the surface to the chert. So actually creating a fracture network which is appropriate for the derivation of hydrocarbons out of this formation has not yet been solved. Companies are trying, though, and we see evidence that wells are being drilled and stimulated that are starting to have longer laterals. So where the state goes in terms of its oil production, much less than its gas production, is unclear.

So the upper left figure is a figure that, as a geologist -- I'm a Geochemist -- it shows methane in cores taken from Antarctica and glaciers around the world. And what it shows is really the impact of human activity since the industrial revolution with respect to methane. Getting the natural methane flux is very very difficult. For nine years I ran the global effort in scientific ocean drilling and the drill ship would report that, no matter where they were, seeing bubbles of various magnitude come up. In fact, methane released from the oceans is actually a ship hazard. Often you read about a ship that disappears without ever a distress signal or anything, and most likely it's an eruption of a large bubble of gas that causes the loss of buoyancy of the ship, and it just sinks out of sight in a matter of seconds.

But you see that up until about the late 1800's the methane that's recorded in gas bubbles in Arctic ice and Greenland ice held steady between 600 and 800 ppb. And then since the Industrial Revolution, it has about doubled and so it's a very serious issue that we have to pay attention. Elizabeth has already gone through the different sectors in which this occurs, the lower left shows agriculture, energy is that rust colored sector on the lower left that's in the range of 25 percent.

So in looking in detail, there's already been discussion of the challenges around Top-down and Bottom-up assessments. There are starting to be many more Bottom-up assessments where we look at the various details of what goes on in the oil fields, how wells are completed, how the hydrocarbons are accumulated, pumped through pipes, compressed, etc., and the challenge of course comes in trying to compare that with the Top-down where you look at a broader area. And then the role of super-emitters which has already been referenced where it could be that a very large percentage of the leakage comes from a very small number of sources. So it's a complicated problem.

But if we look in the oil sector itself, where's the place where we might actually put a lot of energy into -- where's the bang for the buck? And you can see in the purple -- it's around what the industry calls now "green completions," and then how we actually lift and compress the hydrocarbons out of the wells themselves. And so it appears as though about 40 percent of the emission problem, if we want to call it a problem, and I think it is a problem in the oil and gas industry itself, what goes on amongst the drilling and pumping and moving around of hydrocarbons, is really in how we complete the wells, and then what we do with the hydrocarbons as we get them out of the well and put them into a pipeline. And that's roughly 40 percent of the problem.

The other parts of the problem probably have lesser amounts of bang for the buck. Certainly our compressors, how we compress gas and keep it moving in pipelines, it starts of course in the oil field where it's compressed initially, but continues, is probably another area of a big bang for the buck, as well.

So there's a lot of work still to do to understand the system and what happens in California. In my view, California is going to undergo very rapid change in its oil and gas sector and that has to do with a lot of issues having to do with aquifer exemptions and, you know, the state produces 15 barrels of water for every barrel of oil that it produces, and so what happens with that produced water, where it goes, what it's used for? We're on the leading edge, I think, of a major change. And it may be that these changes can take place as we modernize the oil and gas industry in the state and deal with a lot of these methane leakages along the way.

So I hope that gives you a broader context of the oil and gas industry and I'm happy to answer any questions. Thank you.

CHAIRMAN WEISENMILLER: Yeah, thanks for your participation today. I guess my first one, thinking back to your slide that showed Belridge and LA, you know, decades ago, so how many existing wells do we have in the state?

DR. BOHLEN: We have about 70,000 active oil and gas producing wells in the state.

CHAIRMAN WEISENMILLER: How many inactive ones?

DR. BOHLEN: That’s a good question. The ones we know about, we’ve got about 20,000 idle wells and we’ve got another somewhat unknown number of abandoned wells. One of the challenges is that we’ve paved over a lot of our giant oil fields. LA had Saudi Arabia class oil fields for a long time. But we’re looking at tens of thousands to hundreds of thousands of plugged and abandoned wells.

CHAIRMAN WEISENMILLER: Yeah, so I mean the first question is, you know, that, and the second obvious question is sort of worrying about emissions, how much of it is sort of active versus the unknown stuff.

DR. BOHLEN: That’s right. And that’s a really big issue, you know, because the state has had such a long history and well technology has changed from when we tried to line things with Redwood or didn’t encase them at all, to today. And then how the state hasn’t really tracked that leads to a big unknown. And it may be where your Top-down analyses are actually very important because they may pinpoint areas where you may be able to sort out what are these abandoned wells, and what kind of shape are they in, and what are they doing with respect to this issue. But it's an unknown area right now.

CHAIRMAN WEISENMILLER: And do you have regulations that sort of specify what happens when people complete the wells?

DR. BOHLEN: We do, yeah. I mean, in terms of their lifecycle and so forth?

CHAIRMAN WEISENMILLER: Yeah.

DR. BOHLEN: We do. It turns out California is relatively lax in its regulations and we will be undertaking some regulation development over the next couple of years around some of these issues. We're fairly lax. For example, in Texas you can't leave a well idle for more than a year without making some decision about it.

CHAIRMAN WEISENMILLER: Right.

DR. BOHLEN: Including plugging and abandoning it. We allow wells to be idle for a very long period of time. And that's not a good thing for a variety of reasons, for the reason we're here today, but also for the reasons of managing your groundwater and making sure that you are confining the well, the well is confined from your groundwater system. So there's some challenges.

CHAIRMAN WEISENMILLER: Yeah, well part of it, who is responsible for the old legacy oil and gas system in terms of toxicity and just sort of basically cleanup?

DR. BOHLEN: Well, that falls under DTSC and others. It depends on the jurisdiction and it's a complicated issue, again. And one that I'm not actually very well versed in.

CHAIRMAN WEISENMILLER: Yeah, no, I was going to say I know the PUC has ongoing programs dealing with the old gas production facilities, which obviously tended to be surrounding 1890 urban areas, which probably means downtown San Francisco now.

DR. BOHLEN: One of the challenges for the division of oil and gas in the state is that it has a dual mandate, it has a mandate to assist in using all technologies to assist industry to get oil and gas out of the ground, and at the same time minimize the environmental footprint of that activity.

CHAIRMAN WEISENMILLER: Right.

DR. BOHLEN: And if I had to characterize how the division has operated in the past, it's been much more focused on the former aspect of its mission and much less on the latter. And I would say that the change is now taking place that it's going to be much more focused on the latter.

CHAIRMAN WEISENMILLER: What sort of technology development programs do you have?

DR. BOHLEN: We don't actually have any technology development programs in the Division. But we are on the lookout for advances and technologies so that we're aware of how our regulations may or may not apply to new technologies that are deployed in California oil fields.

CHAIRMAN WEISENMILLER: Obviously in terms of our R&D programs, there are a lot more dollars on the electricity side than the gas side, say a factor of 4, ignoring some of the advanced vehicle types of stuff, which seems like a mismatch, but I'm also just trying to understand obviously the oil companies have a ton of money, but just in terms of how much of the research dollars particularly on the things that might help us deal with environmental issues.

DR. BOHLEN: Well, the oil and gas operators tend not to spend a lot of money on research anymore, they really rely on the oil service companies, so Schlumberger, Halliburton, Baker Hughes, Weatherford, and so forth. But I view as a deficiency in the Division, actually, its lack of a scientific basis and as a Division, it just hasn't used science in its decision making I think as effectively or as robustly as it really needs to. And that's a change that we're working on right now.

CHAIRMAN WEISENMILLER: Okay, and obviously DOE has a fossil fuels office just in terms of is there any connection between what they're doing and what you need?

DR. BOHLEN: The answer to that question is no, but that's something I'm working to change, as well. I have a number of colleagues at DOE whom I know well and starting to talk about how do we generate -- this really gets back to your research question, how do we start to generate collaborations? There are initiatives inside DOE, the Subterranean Initiative, which actually had $250 million in the President's

Budget this year, and they're looking for sites to actually -- how do we manage the subsurface for all activities, whether it's groundwater withdrawal, or oil and gas activities. So I'm trying to get the division kick-started into thinking about these opportunities and being a leader in those ways. But traditionally, again, the State Division of Oil and Gas has really kind of been in the background and hasn't thought of itself as a science-based regulatory agency and going out and making things happen, and it really needs to.

CHAIRMAN WEISENMILLER: Yeah, I guess actually the last one I was trying to figure, if you look at enhanced oil production in the '70s, it was pretty much taking the crude, burning it, you know, and that was like 20 percent of California's sulfur emissions, and then it flipped to gas for cogen in the '80s, but more recent production, unless it's associated with an existing cogen project, you know, they have the choice of looking at developing a project, bidding into the utilities, going through interconnection process, going through our siting process, or just I assume burning crude, and getting the permit from Kern County in six months and starting production, and I think all of them head in that latter direction. So I'm just trying to understand that that's going to be an emerging air issue there, or --?

DR. BOHLEN: That's a good question, Mr. Chairman, I'm not actually -- really, it's hard to say.

CHAIRMAN WEISENMILLER: Yeah, okay. Well, certainly thanks for your participation today.

MR. RHYNE: Okay, so before we open the panel to questions from the public, I just have a couple more questions. I want to pick up on some themes, and then sort of get the panel's opinion on one thing.

So first of all, this is a theme that the Chairman raised earlier I think in Elizabeth's presentation, but I'm going to pose the question broadly to the panel and I'll ask anyone who wants to weigh in to join the conversation.

So the question of variability and uncertainty has come up repeatedly throughout the day. Where would you say the largest source of variability, now, that can be geographic, temporal, it can be based on types of sources, where would you say the largest source of variability is in terms of fugitive methane emissions? And then where would you also say the biggest source of uncertainty is? And if you don't know, you don't know, but I'm curious as to what the panel as a whole thinks on those terms.

DR. BOHLEN: Good question!

MR. MAGEE: Well, one source of variability is the detection technology, the quantification of methane emissions. It's still, I think, a developing field, there's still some differences people are trying to figure out between the Top-down approach and the Bottom-up approach, and also quantifying the methane emissions from underground leaks. And then you have variability even in like system-wide leak rates, you have to take in when the gas comes into the system, it's at one temperature, say, and humidity, and when it comes out of the system through all of the various meters, you have to adjust for humidity again and pressure and temperature. So there are some errors in the system leak rate calculations just because it's difficult to determine the amount of gas coming in and the amount of gas actually leaving. So that's one source of uncertainty.

DR. BOHLEN: An area of uncertainty that I think is important for us to understand and get a handle on is we do know enough to know that there are very large leaks that account for a large proportion of the leaking that we think is going on. And I think the question is, is that a stochastic -- are those large leaks stochastic? Or is there something systematic in the system where we can anticipate that those large leaks are going to occur and focus our attention then? And I don't think we know that yet, but I think given that there's this relatively small number of large emitters, that's going to be critical to sort out.

MS. SCHEEHLE: I'll just follow-on on that. I think, I mean, you hear a lot about the fat tail and the super-emitters and I think that is an area among all of the sources we see and some studies look at pneumatics and say that, and pipelines and say that, but I think one important thing to remember is that even though there's uncertainty in those things, there's still ways that we can address them and that we can mitigate them now. I think some of the things we're looking at in leak detection repair will help get to that, and also will provide us information in our draft proposal for the production side we're requesting, reporting on that so we can understand what's been found and have a better understanding going forward.

MR. GRAVELY: So you made one comment about the amount of research; obviously from the perspective of the amount of research we do in natural gas and the amount of research we do in methane emissions, it's very small in relationship to the problem. So I think, as Guido mentioned earlier, we're beginning to find information, but to make a correlation and be able to determine how good a predictor it is, there just isn't enough information out there, so I think, you know, to really get the information being requested and understood here today, you'd need to substantially increase the level of research to be able to get the information and the models developed to give you credible answers. I think now it's still uncertain, we create as much uncertainty as we are answers, I think, with the research.

MR. RHYNE: Thank you. And my last question before I open the floor, the AB 1257 Report is due to the Legislature in November of this year, but obviously this issue is not going to go away in November of this year. And I would ask the panel what research or work do you see that's ongoing today in the near horizon that may stretch out beyond the November timeline that you're the most interested or excited about in helping us understand either how best to assess the fugitive methane emissions issue or, on the flip side, how best to mitigate? So what are you most looking forward to that you're aware of is ongoing? What research, what areas of study?

DR. BOHLEN: I'll jump in. I think merging Top-down and Bottom-up assessments is essential to really understand the whole problem. And that's of greatest interest to me.

MR. RHYNE: Is there a particular study that you're thinking of when you say that?

DR. BOHLEN: No.

MR. RHYNE: Okay.

DR. BOHLEN: Progress in that whole area is really critical.

MR. MAGEE: And there's also progress

that ARB has already completed or is in progress with the utilities. Like in the report that I did, the ICF Report states that compressors are the largest source of methane emissions, but ARB has already been working with the utilities to improve and replace infrastructure surrounding compressors in reducing leaks. So the national picture is more of equipment-related emissions, but ARB is already working with the utilities to reduce that, so that in California, according to the ARB, in California most of the leaks are actually pipeline leaks and the utilities have already been doing quite a bit of work, both compressors and also with pneumatic -- switching over to different pneumatic controls that don't use gas to operate. You can use compressed air to operate, but there are some cases where you have to use natural gas. But you can reduce the amount of leakage using different types of equipment, or different packing. And some of it is maintenance, too. I mean, some of the leaks like in oil fields and places like that can be due to just not maintaining the equipment and not keeping the valves, the packing adjusted on the different pieces of equipment. So the utilities have made some improvements to the equipment in the state working with ARB.

MS. SCHEEHLE: Yeah, I think that we do have a lot ongoing in terms of what we're achieving in the mitigation in the next few years, both through the ARB process and working with the PUC on the pipeline process. There are a few things that we're looking to get more information on, I think some of the information that's coming out about liquids unloading and what are the sources there and the mitigation options there, that will be very interesting to follow in the next few years. And the information we'll be getting in on how effective and what some of the sources are in the leak detection side, and I think looking at the pipeline information we're getting in from our own studies, as well as outside studies, will help us focus on what are the remaining big sources there, and then we definitely have some interest and are considering whether to fund some things on abandoned wells, how big is that problem, as well as some other issues.

MR. GRAVELY: I think in the area you mentioned before in safety and natural gas, the area of research being able to do non-intrusive detection of leaks and being able to determine whether it’s infrared or whether it’s radar or other technologies, and trying to get the capability to do broad coverage of the underground pipes and their leaking, as opposed to necessarily being able to do it through the pigs, there’s much more detail, but they also are intrusive. So I think some of the research we’re doing is trying to look for ways to get as much credible information as you can from a broader area without having to do the intrusion into the system, or not having to dig up the pipe, and being able to do it with some type of technology that gives you credible information and can predict the leaks and the intrusion that they’re having from different people. So I think right away in getting into the areas where people are potentially causing problems and avoid those are areas that we’re focusing a lot in the future now.

CHAIRMAN WEISENMILLER: Yeah, but isn’t part of that question besides location of the pipelines? I mean, my impression was over the 50 years or so we’ve been doing that, that unfortunately PG&E doesn't quite know exactly where the pipe is in the ground, it knows roughly, and the more we can pin down in a non-obtrusive fashion exactly where it is, and I assume at least from a safety perspective we'll be much better off.

MR. MAGEE: Well, the utilities can talk more about that this afternoon, but they know where the major pipelines and the major mains are, and they have a big GPS program to locate all their main distribution pipes and transmission pipes. The difficulty is where some of the distribution pipes are, the small pipes that go to the residences, and knowing exactly where those are located and which ones are plastic and which ones aren't. That's more of an issue. But as far as the emissions, the leaks, I mean they've had leak survey programs going on for many years and they know where a lot of these big leaks are, but it's just never been cost-effective before, I suppose, to fix them because they weren't considered safety hazards, and so therefore they didn't fix them. So there are a lot of emissions out there and leaks that it's known where they are, and they can find them and repair them now.

MR. RHYNE: Okay, thank you. I've been reminded that we've bumped up against our time limit here. I want to take just a moment and thank the panel, thank the members of our sister agencies who are engaged on this issue of fugitive methane emissions. I know that we're going to be talking about it more throughout the remainder of the day and hearing a number of other perspectives. But it is important for us not just because of this legislation, but also because we are integrated in many respects in our activities in this area, and so I want to express my thanks to the panel for being here this morning. There is a period if you have comments, there is a period reserved at the end of the day for public comment. We would invite you to hang around if you do have those comments, you will be able to share them at the podium at the end of the day, or if you have comments we also want to encourage you to submit them in written form. The information for doing so will also be presented later on today. So again, thank you very much for your participation and I will hand the meeting back over to Anthony -- I'm sorry, to

Heather.

MS. RAITT: All right, thank you. If you could go ahead and take your seats, very much appreciate your participation today. And then we'll have the next panel come up on the National Research on Methane Emissions from the Natural Gas System. And so we'll just take a moment to rearrange the room a bit.

So on our panel on the National Research on Methane Emissions from the Natural Gas System, Chris Marxen is the Moderator. If you'd like to go ahead?

MR. MARXEN: Thank you. We are fairly fortunate that there's been a lot of research that has been done recently by EDF, and we've gotten two of their researchers to agree to come here today. So I've been looking forward to this presentation since they agreed to come. I don't know who is going to go first -- Tim O'Connor will go first, and then he'll be followed by Ramon Alvarez.

MR. O'CONNOR: Great, thank you. And Commissioner Weisenmiller, thanks so much for inviting us to participate in this important discussion today. And our presentation is going to in some ways go back and forth, I'm going to present some information, Dr. Alvarez is going to follow me, and then I'm going to pick back up on a couple points.

But I think we've heard thus far about some efforts that California is doing to reduce and manage methane emissions from various sectors, and at a very high level what we're trying to do is evaluate emissions from individual components of the value chain and then in the end put it altogether so we can identify what is the impact of the natural gas system on the environment and how do our policies in California like our investment in natural gas vehicles, or our widespread use of natural gas in power generation, how does that affect the climate?

Indeed, when you look at the importance of this, you know, AB 32 itself says that California needs to manage leakage. And leakage in AB 32 is defined as when you have an emission reduction here in the state it's offset by an emissions increase somewhere else. And we need to manage the things that undermine our efforts to reduce GHGs. And so as we build out a natural gas infrastructure for transportation, or as we use natural gas to displace coal, as we've been doing for a number of years, physical leakage, the leakage from the pipes, the leakage from the production system, the leakage from trucks, if you will, can have an impact and can actually result in leakages, the legal definition of leakage. And so we see this not only as an imperative for the environment, but really as an imperative to meet the goals and aims of AB 32. And as California fits into a framework within which other states in the nation is moving, we want to make sure that our efforts here work within that, for those efforts, and don't pull back from where the nation is going. And I think we're going to be seeing a lot of that this summer.

So as we jump into the presentation, I think we're going to really start off with Dr. Alvarez kind of talking about the fuel cycle and then we're going to go through each of the individual studies that are out here and talk about how it all fits together as sort of just a roadmap, then we'll kind of get back to putting it altogether.

So Ramon, I'll turn it over to you, thank you.

MR. ALVAREZ: Good morning, Mr. Chairman. So just to emphasize a little bit of what Tim just talked about, when you consider natural gas at your home, at your business, your vehicle, your power plant, the emissions burden that results from the point of combustion doesn't tell you the whole story. And that's an issue that I'm going to spend most of my time talking about today, is the methane emissions that occur upstream and at the point of use can have a material effective on the climate implications of natural gas use.

So just looking at it from the standpoint of a vehicle, you have to look all the way upstream starting with the distribution pipes that brought you the gas, the transmission pipes that brought the gas to the distribution, and then the production, gathering and processing of the gas. So a lot of opportunities for emissions all the way along.

About five years ago, Environmental Defense Fund wrote a paper on the proceedings at the National Academy of Sciences that basically said that the methane emissions matter. At the time, there was starting to be a lot of debate about hydraulic fracturing and the emissions of methane from natural gas, and that it could be that natural gas power plants were worse for the climate than coal because of all the methane leakage from fracking. So this paper helped sort of provide a framework for analysis because there was a question, okay, well, how much does methane matter? It's a different gas than carbon dioxide, how do you value the warming effects of methane? Do you use the 100-year global warming potential? Do you use the 20-year global warming potential? We propose a framework that basically looks at the time dimension explicitly, all across time, from the time that you make a decision to invest in natural gas fuel versus coal, or diesel for truck fleets, all the way through time. Long term, the answer is determine by the CO_2 emissions. So if you have less carbon in the fuel like natural gas does relative to diesel or coal, you're going to be good for the climate. But in the short term, the methane emissions drive a lot of climate impacts and, if you have enough, you actually may be doing more harm to the climate even though you have less CO_2, the methane is doing more damage in the short term, so this allows you to look at that effect.

We were able to define some thresholds below which you could be sure that you were doing good for the climate on the short term and the long term.

We've recently provided a new analysis that updates the work from 2012 looking at truck fleets. There was concern at the time of the original work that we talked about diesel truck fleets, but the data was based on data for transit buses. They have different duty cycles, so they're not as efficient, so the question was is that a fair comparison for a truck fleet?

So we've done this new paper where essentially we call out that there's three major parameters that are important to do this, to answer this question, is gas trucks for transportation goods movement better or worse for climate? You've got to have the emissions upstream, the emissions in use, methane emissions in both cases, and the efficiency of the vehicle. No big surprise all three of those parameters matter; this new paper essentially examines a variety of inputs to those parameters and indicates that under some combinations of those, if we can reduce emissions upstream, in use, and improve vehicle efficiency, you can have natural gas trucks being good for the climate; if you don't under current data, best guess data, you could have 50-90 years of climate damage, depending upon the kind of truck engine that you're using.

So long term? Good for the climate, but in the mean time you're going to have 50-90 years' worth of climate damage and the question is, is that a good policy decision to make for the state of California or the Federal Government? For fleet owners? What this points to is there are things you can do to affect the equation so that you can actually be producing climate benefits from day one.

As I mentioned, this paper and the previous work was using best available data, mostly from the Federal Government, the EPA, its inventory, and the GREET model that's used for transportation purposes. But there was a lot of questions, especially back in 2012, how good is the data that exists right now? So we undertook the work that we're going to talk about today to try to answer the question better, what really is the emissions? Where are the sources of uncertainty? How can we reduce that uncertainty?

I have a series of slides that kind of just walk you through the conventional way of thinking about climate impacts from fuel combustion or a vehicle, and then sort of this new way of thinking with the methane. So let's just kind of click through these.

The framework that we propose essentially looks at the radiative forcing from one technology versus another, so radiative forcing is simply the first step in the climate change, it's the amount of heat that's being absorbed by the molecules in the atmosphere that leads to the change of events in climate change. If one technology over another has a higher ratio, which means you're doing climate damage that's above the value of one; if you're below the value of one, that means that you're doing climate benefits.

Conventionally, what people think about is the CO_2 emissions, so the light blue line at the bottom tells you that CO_2 emitted per unit of fuel consumed, it's about 30 percent less for natural gas than for diesel. That doesn't tell you the whole story because natural gas engines are not as efficient as diesel engines, by and large, there is depending on the type anywhere between five to 15 percent less efficiency per unit of fuel consumed to go a mile, natural gas relative to diesel. So in fact it's about 20 percent better when you consider the loss of efficiency, a natural gas truck relative to a diesel truck in terms of the CO_2 emissions.

But as I mentioned, the methane is a lot more potent than CO_2, 84 times on a 20-year basis. The 20-year basis is just one point on a curve, it starts out that a single methane molecule is 120 times more potent than CO_2 and that decays over time, methane is removed rapidly from the atmosphere. By the time you get to 100 years, you get to the value that most people know, it's 28 times more potent. So this decay function drives the short term implications of the methane.

So when we put it on this slide, you get a curve that looks like this. So now what you see is the full time dimension, long term it starts to approach that 20 percent benefit, but in the short term the methane emissions are increasing radiative forcing, increasing the climate damage, so that you start out somewhere above 20 percent worse for the climate than the conventional diesel option, and somewhere around 90 years you start to provide climate benefits. So this is the point, this shows that the methane matters, you can do the same kind of analysis for power plants, all the lines shift down based on the current available data. This shows you reference cases, if you click through the next one you're going to start to see sensitivities around let's change the assumptions, so if the efficiency penalty was eliminated, you would have the green line and you would start probably around 10 percent worse rather than 20-some percent worse. If you removed the emissions at the vehicle level, again, you move it down but you still have a slight penalty at the beginning. If you remove the upstream emissions altogether, then you start out better for the climate from the beginning. And if you combine them altogether, you get that theoretical curve of around 30 percent less and so that's the theoretical maximum you could get just in terms of the CO_2 emissions and no methane, so that's the best case.

So that just gives you a framework to think about this, the studies that we're doing now that we'll talk about, will start to provide data that we can see how good the data is that we're using for this model. You can update it and, as we finish the work, we'll be updating it with those new values.

This just shows you one of the slides from the paper that shows you different technologies with the different sensitivities that we ran. Okay?

MR. O'CONNOR: Thank you, Ramon. And if I could just jump in here. I think it's valuable to see and think about this in terms of turning the dials, you know, if you turn down the dial on leakage and you can turn down the dial on onboard emissions, or turn up the dial on efficiency, you certainly can imagine that even using fossil natural gas you can provide a net climate benefit in trucks as power generation, but if you don't manage those dials and if you even in some ways turn them up because of other productive techniques, or other things, you can certainly start to make the climate impact worse. Of course, we haven't talked here about using other sources to produce the natural gas like biogas, biomethane, things of that nature, which then you start to take off some of the other impacts, of course. But then if you let that leak into the air, then we have another range of impacts. And so these studies that we're going to go through here really do talk about sort of the production of fossil natural gas, the idea of using biogas is not really captured within these studies, but it's something that of course warrants attention, especially insofar as methane is leaking into the air anyway, especially from the decomposition of organic material and to the extent we can capture that, keep the leakage of that low, and get that into the pipes, you can only provide an additive climate benefit, as long as we take care of other needed issues associated with ecosystems and their effects.

And so I just wanted to add that side note and I think what we'll do is jump into the studies, kind of what we were sort of brought here to really talk about, and we'll put it altogether at the end.

MR. ALVAREZ: So maybe this is a good time to pause and see if you have any questions sort of on the context. Normally when I do this talk, which is getting longer and longer as we finish the studies, but it's 15 or 20 minutes, so I'm going to talk more than usual, but I want to make it as valuable for you as possible. So if you want to ask questions now, or during the talk, please feel free.

CHAIRMAN WEISENMILLER: No, no, that would be good. Let me start with at least two basic ones. Just a footnote, my undergraduate training was in Chemistry, so when you talk weight instead of molecules, of course, I sort of wince a little bit, although I don't think it changes the conclusion, but again we always taught students to think molecules were where reactions occur. You know, and certainly weights are much different between two molecules, as CO_2 and methane. But anyway, again, that's just sort of a whatever, Undergraduate, well, you would not get out of the U.C. Berkeley Chemistry Department Undergrad, you know, talking weights and not molecules. So anyway, footnote 1. But I mean, on the interesting policy question, as Tim understands, one of our big issues in California is that 20 percent of the economy in Los Angeles is goods movement, and certainly as we look at the air quality impacts, we're struggling on how do we maintain the economy, reduce greenhouse gas emissions, and get the cleaner air there, and sort of what are our choices. And obviously there are some arguing about switching to the natural gas, and then you're back to the question, is it renewables? Where do you get it from? But that seems to be one of our huge economic issues in the next, say, 10 years is how to deal with goods movement in Southern California while cleaning up the air and dealing with greenhouse gas emissions. So back in your overall study, what are the three or four things we would need -- how can we make progress on those fronts down there?

MR. ALVAREZ: Yeah, let me just make a caveat that everything that I talked about in terms of fuel switching trucks from diesel to gas focused just on the climate impacts, and there's a lot of other considerations including economics, including local air quality. I've spent most of my previous professional career working on the conventional air pollutant side and especially, you know, a decade ago and before, natural gas vehicles were dramatically better than diesel. Federal Standards on diesel engines have improved so the margin is smaller than it once was, but from an air quality standpoint, that's a completely different set of considerations, that's one of those things you've got to weigh in terms of the costs and benefits for a region like the LA Basin what you do.

So we'll go through the studies and, again, please stop me at any time. I'm going to sort of give you a sense of what we've learned so far, try to put any insights that I think might be relevant to the California situation, knowing that you don't have as much production of gas per se down here, but when I can I will try to highlight that.

Just again, just emphasizing that the supply chain, you know, that the methane emissions no matter where they're released are going to damage the climate, so you need to sort of account for those as you consider the fuel use.

We've seen slides about the contribution of oil and gas emissions.

And again, this is a partial slide of what I saw before, which was excellent, knowing kind of where your gas comes from will be very valuable to really do in the attribution of impacts. You asked a question about do we know kind of what the variability is basin to basin, I think it's fair to say -- and I'll talk a little bit about this -- that there is variability. The work that's been done from the Top-down so far shows that numbers range from anywhere from less than a percent of gas produced in a basin to upwards of seven percent. The averages if you look sort of at larger scales, national or international scales, the averages tend to cluster maybe around two percent, four percent internationally, so you can't have everybody emitting at seven percent for the math to work out. But there will be some areas that are higher, some are lower, and I think opportunities, you know, basin specific based on practices, or the kind of technology that's used there, to address emissions, but knowing where your gas comes from is an important part of the process. Next slide.

All right, so 16 studies with a lot of industry partners, leading academic institutions, and research firms. The projects are led by academic scientists, we have essentially like a principal investigator on each project. They are responsible for the design, execution, and analysis, as well as the publication of the study which is another key point, is that all the work has to be presented through the peer review literature to try to make it as robust as possible. The academic principle investigator does interact with the sponsors. EDF was one sponsor of some of the projects, an entire sponsor for some of the others. The principal investigator received input from the sponsors, but ultimately all the decisions were theirs. We try to use multiple methodologies to try to avoid missing things, to try to make sure, for example, using Top-down studies to see that we were capturing everything, it's always hard when you're doing Bottom-up to know that you've got everything and you've got it right, so the Top-down studies help provide confirmation.

We had scientific advisors that were independent of the study that reviewed some of the methods and analysis, as well. And all the data will ultimately be made public as results are published for hopefully others to use and mine as much value as possible from those.

This infographic kind of shows you the supply chain, which is in the background starting on the left at the well sites, and on the right side all the way through a hypothetical refueling station for trucks. We have studies that address each part of the value chain, we did one study that looked at a particular end use, the one for heavy duty trucks, just because there were a lot of question about that.

So I'm just going to go through these and it shows you that there's an aircraft at the top that we did some Top-down studies, as well as Bottom-up projects, and we're starting to work on that reconciliation which I agree with the speakers earlier, that that's kind of an important area for reducing uncertainty going forward, is sort of understanding those and seeing whether they're agreeing or not, and I think the emerging picture is that they are starting to agree, which is good. Next one --

CHAIRMAN WEISENMILLER: Actually, let me stop you for a second. So flip back. So I think when this legislation was originally passed, our hope was that the EDF studies would be completed before we got to the stage of trying to write something up. And obviously some of these are done, some are submitted but not public, and then others are not submitted? Or almost -- anyway, so looking out, at this point what’s your best guess when everything is going to be done and wrapped up?

MR. ALVAREZ: I wish that we were doing this presentation in six months and that your schedule would accommodate that, and we had hoped to be finished by this point. Science takes longer than you always expect, and at the end having the deliverable be a peer reviewed publication really raised the standard of the work, and the time required, you basically had to add five to six months at the end of each project for that publication process to play out. So I’ll give you an update on where we stand on things. I do think that by November everything should be out, but you guys have to, for the report, have to have information before that to get it into the report that publishes in November. So it'll be a little bit of a challenge, but we're committed to working with your staff to provide as up to date information as we can right up to your submission deadline for the report. I think what's going to be missing, that what you may not have at the end, is going to be sort of the overall what we're calling the synthesis of all the work; it's our 16th project, which is really just pulling them altogether and saying in the most simple term, what is the leak rate? And it's going to be a national level leak rate, probably with some acknowledgement of the variation from different basins. But that's going to be the last one to come. We're still waiting on some of the results to really start that process, but it probably won't be submitted to a journal until I would guess August or September, and then a couple, three months to get it published after that.

CHAIRMAN WEISENMILLER: The other question is, even assuming magically we could slide dates, you are back to -- presumably you've learned a lot from what you've done so far, is there going to be a Phase 2 where you're basically going to try to show gaps or --?

MR. ALVAREZ: The 15th of the studies on the bottom is a little bit of gap filling and so, as we went, we found some gaps. Abandoned or from wells is one of them, the super-emitters is another one, it's not really a gap so much as it's a special problem in this field. And so there will be some questions to answer there, but there will be some remaining gaps. The only further work that we're envisioning right now is other end uses, including potentially what's going on behind the meter, and I was glad to see that you all are sponsoring work here to do that, I think that's a big question. I think one of our studies, I might as well just mention it now since it's relevant, the Boston project, which is number 10 there, they did a series of towers, three or four towers in the Boston area over two years roughly, and were able to estimate how much emissions of methane were occurring in that region. And what they found was that total emissions, not unlike what you found in California, were higher than the estimated emissions from the best available inventory that the State of Massachusetts had prepared. And with some ethane as a sort of way to attribute their methane from landfills and other biogenic sources from oil and gas, you know, they determined that the methane emissions in terms of the throughput of gas in the region was -- I think it was 2.5 percent or something like that, about two times higher, maybe three times higher than the inventory. And one of the things that they are positing in their results, because they don't know, is so where's that excess coming from? They're thinking it's coming from behind the meter because based on all the data on individual components of the natural gas infrastructure, it doesn't seem like that adds up, so there must be some missing source and behind the meters is one of them, and so we envision doing some additional work to get to that question.

MR. WEISENMILLER: Are you doing any work in the non-oil and gas, but the other emitters? You know, biogenic or --?

MR. ALVAREZ: Oh, not directly in terms of quantification, but you know, I think this is probably getting a little too in the weeds, but the inventories for the biogenic sources seem to be pretty good in terms of the sort of overall biogenic and fossil attribution that you see from the Top-down studies. The landfills have a particular degree of uncertainty with them because there appears to be a variability in emissions due to meteorology, the pressure and changing pressure kind of affects the flux out, and so it's another one of those sources where if you just did like a one-day snapshot on a particularly emissive day or low-emissive day, you may kind of miss the landfill signatures. So I think one of the lessons from the work is that if you're doing single measurements, you need to sort of be cautious about how representative it may be from typical operations, or the point earlier about annual emissions. So you want to get kind of multiple measurements and see how that temporal variability can be averaged out.

MR. O'CONNOR: One thing I would like to add is we have discussed the timelines associated with some of the studies that have been submitted, but are not yet public, and it does look like some of them will be ready and public prior to the final submission deadline for the report, and so we've been speaking with your staff to evaluate that and we'll make sure that we feed that in as soon as they're ready.

CHAIRMAN WEISENMILLER: Okay, that's good. And certainly the basic question of what are the four major uncertainties, and what can we do to try to deal with those, we'd certainly love to get EDF's input on that, either now or in writing.

MR. O'CONNOR: Well, spoiler alert, we're going to talk about that at the end. I think the two of those we've heard about today in terms of the regulations and the efforts that California is proceeding with, number one on the oil and gas side, we heard Elizabeth Scheehle from the Air Resources Board talking about what the State is doing. I think that what Ramon has already shown in terms of the super-emitters problem we've kind of discussed, is quite relevant, that the proposal that's on the table right now with the Air Resources Board seems to be insufficient for dealing with that issue. Currently the proposal is to allow oil and gas operations in California to go with an annual inspection period frequency at their sites. And really, that is insufficient for dealing with the random occurrence, or the inability to know when and where super-emitters may indeed pop up in oil and gas production and there's a number of folks in the environmental advocacy community that are really focusing on this particular effort, to make sure that the rules in California are as stringent as possible with regard to the inspection frequency. And indeed, when you look at what effect loose California rule may have on the U.S. as a whole, when the Bureau of Land Management and U.S. EPA are going to be proposing rules for oil and gas production later this year, and where we see other states, Colorado, Pennsylvania, Wyoming, already having gone to quarterly leak inspection requirements, to have California take a step backwards could have ripple effects throughout the U.S. Economy in terms of the inspection frequency of oil and gas operations. And that's one thing where California can make significant progress, is by having a very stringent oil and gas rule.

And the second point, we've heard about SB 1371, which the CPUC is implementing right now, we're a party in that proceeding, and implementing that bill to its natural extent which would require utilities really to quantify emissions from their systems so we can figure out where the biggest leaks are, and so we can prioritize investment in that, and to not allow some of those leaks to persist for extended periods of times. We see from some of the utility reports that leaks have been in the system for over 20 years. A single leak may persist for over two decades, it could be going to a party and drinking alcohol at this point. At this point, I think when we look at 1371, there are some really low hanging fruit and some things that the PUC and the utilities really need to be doing to putting that best effort forward because we're the first state in the nation to do something like that, to do something like this bill, and if we do it right here, we think that just like the oil and gas rule for production, we can see pretty dramatic benefits across the U.S. on the energy system.

CHAIRMAN WEISENMILLER: Is EDF doing anything in the area of developing a risk assessment framework for 1371?

MR. O'CONNOR: So far we haven't

evaluated that specific issue, but that's definitely a point worth noting, I mean, I'll talk a little bit offline about how we can think through that issue.

CHAIRMAN WEISENMILLER: Okay, thanks.

MR. ALVAREZ: Okay, next slide. I'm going to come back to the question, again, about some lessons learned or reducing uncertainty, Tim already gave you a preview of that.

And let me just also say that it's a real pleasure to be here today to listen to a lot of the good work that's going on in California. As a former grad student at U.C. Berkeley where we learn about molecules versus pounds of gasses, I've always been an admirer of the environmental ethic in California, so it's really nice to see all that you're doing and I appreciate the invitation.

We're going to tell you sort of a snapshot of what we're learning, but it's by no means the only organization involved in doing work. Other states and other organizations are doing more work, so in the last five years we've learned a lot and probably in the next five we're going to learn a lot more, too. But I don't want to make it sound like we have the monopoly on knowledge here.

So I'm going to talk about 10 of the studies that have been released already. The next three slides just kind of summarize the citation for each of them, and then we'll sort of go individually and I'll try to give you a little snapshot of high level insights from each one.

So the first one that came out was production and this one might have been the most anticipated one of them all because it dealt squarely with the biggest question at the beginning which was, hey, this hydraulic fracturing process, how much methane is release when you complete the well? And the answer was potentially a lot. So the difference here is one about potential emissions and actual emissions. I think early on when the process was started in the mid to late '90s, there probably was a lot of emissions being emitted each time a gas well was fractured and completed, sort of brought on to production, when you had the flow-back where all the liquids and materials come out of the wells sort of to clean it out to start producing. There were a lot of efforts made in the first decade of the 2000’s to implement practices called green completions to capture some of that gas, and by the time that we were doing the study, most of the wells that were evaluated had that equipment on site and so essentially 95-97 percent of the potential emissions were being captured or flared, so the process was not that emissive from the results that we had. Now, there were some wells that were not controlled, they tended to be lower potentially emitting wells, and then the question is, you know, is that the norm? Since that time, the EPA has adopted standards that apply to all new gas wells that should require the use of green completions or flaring. So by and large, the lesson from that part of the work was that green completions work to reduce emissions, they seem to be widely used at the time, and if not they will be because of the Federal Regulations. However, that applies to gas wells and, as we’ve heard already today, California has a lot of oil wells and potentially a lot of new oil well hydraulic fracturing going on. Federal Standards do not yet cover oil well completions and as evidenced in the Bakken and in the Eagle Ford Shale in

Texas, the oil wells can have a lot of gas associated with them, and a new oil well can have plenty of potential emissions of methane. If you don't use a green completion, you could have a lot of methane there, so that's an important gap in the regulatory system right now. You know, we can estimate what those emissions can be based on data from like the greenhouse gas reporting program and it can be significant. It's not quite as high as a new gas well, but you know, 50, 75 percent of the emissions are not out of the range of possibility there. So if that's a growth area for the State, it's something that you definitely want to watch out for because this result will not tell you -- you need to look at the potential emissions, rather than the actual emissions from this study if you do that.

So this study also looked equipment leaks, it looked at pneumatic controllers, and pneumatic pumps. And what it found for those were that those were generally higher, the emissions from those were generally higher than what the EPA estimates were, unlike for completions, those were all higher.

Phase 2, next slide, because liquids

unloading which they had some preliminary data for in Phase 1, and pneumatic controllers were such a large portion of the emission inventory, the Federal inventory, we felt like it would be useful to take a closer look at those two sources and for those the conclusion was that liquids unloading were a significant source. The emissions were largely in line with what EPA estimated in the aggregate, but there are different practices with plungers and without plungers, the share of each changed a little bit, but that one is one that requires more attention. It's good to see that the State is also looking at some improved reporting for that source, and I think the good news on that one is that there appears to be strategies to minimize those emissions. BP has done a lot of work that's been published through the Natural Gas Star Program where essentially you try to optimize the unloading schedule using plungers so that you let the reservoir do the work for you and you don't actually have to vent the well, so you can almost eliminate the emissions.

The pneumatic controllers, those emissions actually appear to be even higher than

I believe in the first phase, and there's questions about the emissions from continuous vent devices versus intermittent vent devices, but there's also a big question about how many devices are out there and the observations from the survey were that there may be two or three times as many controllers out there as are estimated in the inventory. So you take a higher emission factor and a higher population, and you get a lot higher emissions. So that's one where, you know, if there's underestimates going on, that's a possible source of why.

One last point I would make about this specific to California, in sort of following this issue I've recently seen some infrared camera images of California operations that pointed to some of these like liquid storage ponds, or evaporation ponds, and a lot of emissions coming out of those. That's not an area that we've studied, it sort of seems to be, I mean, liquids are produced with a lot of our natural gas operations, produce water, condensate as well, they're normally stored in tanks and those tanks can be controlled. I've seen in some states they do have more of these ponds. I would say that's an area for future work, there's a lot of water that is produced, I think disproportionately larger in other states than here in California, that the potential emissions of methane, as well as BOCs from that is an area where it's a gap in the work that we've done. Next slide.

Along the way, one of our goals was to try to get as much information out there into the literature, into public use. EPA had done some work doing some mobile measurements around well sites in various basins around the country. They presented it in conferences and we asked them, gee, you know, it would be great if you could get this into the literature. They didn't have resources, so we did a cooperative research agreement with them, brought in some analysts, and they ultimately ended up getting the data fully analyzed and published in *Environmental Science and Technology*. And one of the interesting findings there, this starts to get to that super-emitter lesson that we're finding repeatedly, not just in our work but others, that very skewed distribution, small number of sites appear to be having malfunctions that were leading to higher emissions, but, you know, nothing earthshattering about the magnitude of results, just that it was a skewed distribution, some of the results were comparable to other work that had been done Bottom-up, but slightly larger. Next one.

So gathering and processing, actually two of three papers on this project have been published already, one was the measurement technique that was used, and the second one was the result of the measurements; 114 gathering sites and 16 processing plants. High level findings are that gathering facilities can have high emissions, these are compressor stations, not unlike transmission compressor stations, typically a little smaller, perhaps less regulated, but the emissions can be comparable to a large transmission compressor station.

The processing plants show that the emission factors from the processing plant were smaller than what is in the inventory, so perhaps due to regulations over the 20 years or so since the inventory factors were developed, there’s been improvements, so it’s probably the most regulated sector of the industry, the processing sector. So emissions tend to be lower there than the Federal estimate.

The remaining papers, the one that's going to bring it altogether and say what are the total emissions from the gathering and processing of gas, and that's been submitted, I expect that will be published by the end of the summer, probably in time for your report, for sure.

CHAIRMAN WEISENMILLER: It's interesting, PG&E used to own and operate the gathering system on Northern California and I'm not quite sure where it ended up, but there's a real push for that to be basically spun out, a fairly old system so, again, I'm not quite -- some was the individual producers wanted the gathering facilities that gave them more flexibility in order to sell. But that could be an issue in California, the Northern California gathering system.

MR. ALVAREZ: One gap in this work was that because of the logistics, the gathering pipelines were not within the scope of the study, so we studied the facilities, but gathering pipelines will remain a question mark at the end of our work, that needs to be addressed.

I mentioned multiple methodologies, so we did two projects with the University of Colorado Boulder, a group that is affiliated with NOAA, and they flew in the Denver Julesburg Basin and they flew in the Barnett Shale. In the Denver Julesburg, they found that the emissions were higher than predicted by the inventory, this is one where they found about four percent of gas produced in the region was being emitted after they accounted for the biogenic sources. They didn’t have the benefit of a tracer gas to do the attribution, so it’s based on kind of an inventory-based attribution, so there’s some uncertainty around that. But roughly four percent of the gas produced in Denver Julesburg was being emitted. And that was in agreement with the previous project that group had done, not related to an EDF project.

Not one of our 16 studies, but done by the same group, was a study in Utah in the Uinta Basin. They found about seven percent, plus or minus three percent, of gas produced, was being emitted there. So that’s considered like the high end point in terms of observations and, as I mentioned, other groups actually fully a NOAA, just entirely NOAA, did some flyovers that were recently published in four basins, Marcellus, Fayetteville, Haynesville, and I forget the fourth one right now, but they were in the one percent to two percent range. So a lot of variability again basin to basin, so it's important that you not sort of say everyone is going to be right at the average, there's going to be a distribution.

MR. O'CONNOR: And this of course is important, when we looked at one of the slides that was presented by the Air Resources Board earlier today that upwards of 36 percent of California's natural gas is coming from the Rocky Mountain Basin, which is precisely where we're talking about with this study.

MR. ALVAREZ: Next slide. The flyover they did in the Barnett Shale is in publication. We expect that this is going to be out in early July and it's going to be published in conjunction with some Bottom-up work that we did concurrent with their flyovers, so I think it's going to be one of the first sort of combined Top-down Bottom-up coordinated efforts, and I think will produce some interesting insights about how to design those studies in the future and the kinds of measurements that you need and hopefully a sense of how good is their reconciliation, how close are we coming?

Next one just sort of lays out the Bottom-up campaign. We had 12 different research teams making measurements from the Bottom-up; and actually, when I say “Bottom-up” it’s kind of intermediate scale. We had some onsite measurements, but we also had some measurements that you would consider Top-down because they may have been made from an aircraft, but they were focused on a facility, so when I say Bottom-up, I typically would refer to a facility level emission estimate, or a component specific estimate, as opposed to like a basin level estimate which averages all the sources.

Transmission and storage, one of two papers have been published. This is the one that’s published that reports the measurements that were made at about 45 transmission or storage compressor stations. I think the biggest takeaway from this study is that the emissions are individually large from compressor stations. I think you asked a question about where’s the greatest uncertainty or variability and I think one of the answers I would give you is that the capacity or throughput of a facility is a good indicator of how important it could be emissions-wise, the potential emissions. And so you've got to look at a well site is only going to have so much gas that can be emitted because it's coming out of the ground, but as you concentrate flows into these larger facilities like gathering sites, processing plants, transmission stations, those are ones that need special attention because the emissions could be quite large. And what they saw there was two of the 45 or so sites accounted for something like two-thirds of the emissions. So the super-emitter issue came up.

Local Distribution. This is probably one that is most pertinent to California just because you guys have entirely localized distribution systems here in the state. This was a Bottom-up study, pipeline leaks and meter and regulating stations. The top level result was that the emissions were lower overall than what is in the EPA's Greenhouse Gas Inventory, and the explanation for that, which they interestingly were able to test by going to facilities that were measured in the 1990's and going back to measure them again, was that they found that emissions were much lower at a subset of those facilities that they could find, and it appears it's due to equipment improvements at those facilities, as well as operating practices where they have leak detection and repair programs at those, so emissions have gone down apparently due to operator practices and maintenance and improvement in technology. Also, skewed distribution, so some small number of the individual emissions drove a lot of the total.

So I mentioned the Boston project, so I won't repeat that again, other than to say that we're doing a similar project in Indianapolis.

This is soon to be submitted for publication, similar kind of work where they had towers and in this one aircraft as well to measure sort of the Metropolitan area level emissions.

MR. O'CONNOR: And I'll jump in here. With respect to the Colorado State University methane mapping work, this is a project that the science team did actually do measurements here in California down in the Los Angeles region, and are currently evaluating a fourth city. So far we've released maps of leaks that we were able to determine were coming from the local distribution system in this particular project, using street view cars by Google outfitted with mobile methane monitoring equipment. The researchers drove the cities of Inglewood and Pasadena and Chino two separate times and using an algorithm that was based specifically for this project, we were able to determine relative sizes of emissions coming from individual leaks. On the next slide, we'll see that by looking at the geocoded information, we were able to overlay this onto a map to identify the location of those individual leaks and really sort of create for the first time in California, as we've been doing other places, a publicly consumable set of information about where leaks might be coming from in our distribution system.

On the next slide, you'll see that the results from Los Angeles are actually somewhat similar to some of the other cities that we've mapped, you know, in terms of falling within the range. We're going to be releasing maps of Chicago here pretty soon. We've released similar maps in Burlington, Vermont and Stanton Island, Boston, and Indianapolis, and what we see is really one leak per every four or five miles driven in these systems. But some of those leaks are much larger than others, and using the algorithm that was created for this, we could sort of determine a generalized low, medium or high leak and thus allow for a coarse assessment of where you might want to focus efforts. We're submitting this into the Public Utilities Commission process for the 1371 proceeding as sort of a demonstration of the types of technologies that are coming out to help utilities be able to evaluate leak rates and leak locations and various leak sizes.

But really the fact that we've been able to see these leaks of various sizes in Los Angeles really does confirm, you know, that in California we do have the super-emitter phenomenon, you know, we keep saying that it exists out there just generally, but having concrete evidence of documentation that indeed there are those leaks here in California, that are much greater than others, does provide a helpful context in terms of the storytelling. And when we look at also pairing this with utility leak data that was released on the day afterwards, we can see that some of those leaks are of course of various sizes, but also of various duration in terms of how long they've been able to last for. And then I think to the point where we talked about like what do we recommend, that these types of technologies and the opportunities to evaluate leaks, both using mobile methane and sort of not as a replacement, but as an addition to the existing types of leak detection and quantification that's out there really does have tremendous value. So next slide.

CHAIRMAN WEISENMILLER: Actually, two questions or comments. One of them is that we probably should be thinking, too, in terms of obviously California is seismically active and so in terms of particularly when the earthquake at Napa occurred, I think one of the things PG&E needed to do was go through its gas distribution system, so in terms of as you're doing the checks, one of the things is trying to figure out if there's any sort of metric to tie it to any sort of seismic events.

MR. O'CONNOR: Uh-huh.

CHAIRMAN WEISENMILLER: And the other one is we keep talking about emitters, one of the things to think about is, you know, whether portraying certain results as a cumulative frequency distribution might be ways of getting the message across that, you know, really trying to focus a lot of the mitigation, at least initially, on sort of the high leak, high value parts.

MR. O'CONNOR: Yes, and on the seismic, of course the utilities do present safety plans and they talk about inspections after seismic events just as inspections after other sorts of things, you know. I'm aware that even when we have big events coming to towns in other cities, you know, some of the utilities go do large sweeps just to -- because there's going to be a lot more foot traffic or people around, so there are certain events and things that could necessitate and really get value from more frequent leak inspection. And on the cumulative frequency distribution, I think what you're talking about is sort of evaluating certain types of conditions to determine whether they should be inspected more often, or things of that nature?

CHAIRMAN WEISENMILLER: Actually it's more the presentation. I know at one point when I was looking, say, at Q rep (ph) power production, you know, that literally the top ten might well be 97 percent of the power, you know, if you had a few 300 megawatt projects as opposed to a lot of one megawatt projects, you know, just those really, so again in this context it may be that most leakage is coming from your thousands or tens and tens of thousands of potential sources, but maybe the top ten have a real phenomenal portion of the leaks.

MR. O'CONNOR: Indeed, and in fact in the Los Angeles study, some of the largest leaks we've seen in the entire study were located there and that point is well taken.

MR. ALVAREZ: Okay, so last major study I'll describe is the pump to wheel study, one of the end uses, this is one where they measured emissions from heavy duty natural gas vehicles and CNG and LNG refueling stations. The study has been submitted and hopefully will be out July/August timeframe. This is one with a lot of interest. Because one of the things that I found doing the work is that, especially for the vehicle in-use portion, very little data on that, and so this will help with that data gap.

Let's skip through to the one that just summarizes the studies to come. I'm going to talk about some timelines and then some takeaways. Okay, so what's still coming? I mentioned the Barnett Shale, that's going to be early July for those, it's going to be a series of about 10 to 12 papers on that. The pump to wheels is submitted, in review, as is the transmission and storage scale-up and the gathering and processing scale-up. All of those could be July/August publication, if not sooner. Indianapolis study is close to being submitting. The gap filling is still in preparation, so that one may be later in the year. Project synthesis, we have processes in place to start to bring all that data together, but I don't envision that will be submitted probably until the August/September timeframe, so that one may be a little bit outside of your -- probably the end of the calendar year I would guess for publication of that.

Tim has some other sort of related studies that we're working on to present, but let me just take a quick moment and give you some other sort of takeaways that I think might be relevant for you. I want to emphasize -- we've talked a little about super-emitters, but it's important not to lose sight of the policy implication of the non-super-emitters. I think that the mobile source vehicles, emissions from those over the years is a good illustration, you know, we've had an inspection and maintenance programs and we've had remote sensing, roadside remote sensing to try to flag super-emitters because we know that a few of those have a lot of emissions. And so I think a mediation strategy should include focus on those and we would argue leak detection and repairs, sort of looking out for those, is important to target them and fix them quickly. But let's not lose sight that over the years we've also had increasingly more stringent vehicle emission tailpipe standards, right, that have brought the whole sort of tide of emissions down and so on top of that you've got the super-emitters. So we need an approach that has sort of a cure for the regular emissions and then that also addresses the super-emitters because at any one time, those are the ones that are driving the total.

I think I would also say that abandoned and orphaned wells is an area, we're going to do some preliminary work on that, some recent work was published out of Princeton that had a limited number of measurements in the Marcellus, we're going to add some additional measurements in some other plays. It's hard to do that work because it's hard to find these things physically, and then the measurement is difficult because the emissions may not be coming out exactly where you think the source is, they could be coming out from the ground nearby, so that's touch work but an area of important work that needs to be done. And as I mentioned, in the case of California I think the emissions from the water that's produced with hydrocarbons here is important to take a look at, too.

MR. O'CONNOR: Great, thank you. And next slide. We've been talking about the emissions and where they're coming from. We can evaluate this not only, of course, from the point of how much is out there, but what can we do about it and what is the economic benefit we get from cultivating solutions that reduce emissions and grow the body of technology that's out there.

On the next slide you'll see a cost curve which has already been presented today, which we continue to use as point number one about the fact that this is in many ways a money saver for businesses and, in fact, this type of cost curve is really proof positive why it does pay to move to quarterly inspections and quarterly maintenance, as opposed to annual. You look at leak detection repair being some of the most cost effective opportunities to reduce and manage emissions, we look at the fact that things break without notice at times, and that facilities if we let emissions go for upwards of 365 days, those can be very significant sources of greenhouse gas emissions across the oil and gas sector, and then implementing these policies you can see that nearly 40 percent of reductions can be achieved at essentially cost mutual or at a cost savings from day one.

And as we do that, it will grow and we've been evaluating businesses that are located not only across the United States, but even here in California that can provide some of these solutions, not only businesses that are employing workers to go and turn wrenches in and to fix things, but businesses that are manufacturing the equipment that can go into reduce emissions. And this report that is available on our website talks about the companies located here in California up and down the state that are providing these types of solutions and manufacturing technology that can go into place in oil and gas operations across the U.S. and here in California.

And the technology that's emerging both from these companies and others is something that we've been focusing on with what's known as our methane detectors challenge, where we've really opened up through an RFP and a competitive process an opportunity for individual industries and industry partners to come and showcase their technology and allow us to test it and have it put into use so we can evaluate the best new technology that's out there. And in this particular one, we have industry pilots who will be defining and determining the best technology, then submit it to us in order to try and help advance the ball in terms of methane detection for the purposes of increasing the ability to find and respond to leaks.

And finally, as we get into like the final three slides, on the next one you'll see that this all does fit into a set of activities that are improving the ways that we can quantify emissions, but also to increase sort of what we can get out of all that quantification. And, you know, time and time and time again we see the emergence of skewed distributions, this super-emitters issue, that the national and global studies that are out there that do present ranges of methane emissions in terms of system-wide leak rates, are not necessarily fully accurate and more studies need to be done, and that's why we're evaluating from our synthesis paper both on the U.S. but also noting the region effort, the region-wide variability that will be important.

And as this fits into what California is doing, I think it's important to note that the Energy Commission, of course, has been a leader in investing in, and growing, in doing research development, and deployment, and helping to really commercialize new technologies and technology applications, and we want to make sure that, as we do this, and as we know that some of the proposals even in the Legislature right now, whether they're budget proposals or whether they're implementation proposals from the bills that are already on the books, that those are being done in a way that really takes into account the whole potential impact of the investments. And I think as the leadership that the Energy Commission is in, and so far as it has so much to gain by helping California transition to alternative lower carbon fuels, and to an energy system that is lower carbon overall, we also have so much to lose if the investments are not made with the mindset that there are potential leakage issues with respect to methane that can undermine them.

And therefore I think that there is a need for the Commission's voice, both through this IEPR Report, but through other connected activities, whether it is through communicating in the Energy Principals Group, or to the work that's happening at the Air Resources Board, or to the work that's happening at the Energy Commission, or in efforts like what's happening at the Federal Energy Regulatory Commission in terms of setting standards for leakage coming from interstate pipelines, or from efforts at the Bureau of Land Management, or through efforts at the Western Governors Association which is right now talking through how we get region-wide efforts to reduce emissions and information sharing and collaboration, or through the work at EPA later this summer.

The Energy Commission here has a very strong voice and, Chair Weisenmiller, your voice in this could be very helpful, not only through this IEPR, but through the range of work that is going to be connected to what California does because of the tremendous amount of gas that we import and our need to reduce emissions, both here in California and upstream. So, thank you.

CHAIRMAN WEISENMILLER: Thank you. Thanks for your participation and your work on this. I think actually just a couple of follow-ups with you, I mean, one of them, it seems like if there's a way to really find breakthroughs in sensor technology, that that could move us much more towards real time monitoring. You know, again, you're getting the cost benefits, but it would be sort of interesting as we're going forward if we could sort of really drive the sensor technology along.

The other thing is, you know, obviously one of the things that exists in the Cap-and-Trade is potential offset programs and so the issue in part is whether, as you're trying to structure industrial responses to doing mitigation measures, if somehow this could become an offset, would that drive the programs faster and further. And then we might be able to do it through regulations.

MR. ALVAREZ: Could I just respond to the first one real quick?

CHAIRMAN WEISENMILLER: Sure.

MR. ALVAREZ: I don't think Tim mentioned this as explicitly as I would like, on the methane detectors challenge, I think is in line with what you just outlined, that it's not so much about testing specific technologies, but testing a methodology that would allow you to sort of do real time monitoring of operations, so much like a smoke alarm, you would know that there is something wrong here, operator, pay attention, come send somebody out to fix it. And so I think the sensing technologies are there, the question is what are the systems that you need to build around it so that you could have that and sort of avoid false positives and things like that, so that's where we hope to end up by the end of the pilot projects later this year, or actually they'll be in 2016. But I also want to point out that the ARPA-E has a similar effort, more about promoting the technologies themselves, they have eight or 10 different projects that got funded with the hopes that they could help them through to commercialization. We were not trying to pick winners so much as trying to demonstrate that an on-site system of detectors and information management could help you find these malfunctioning facilities so you could fix them.

CHAIRMAN WEISENMILLER: Yeah. It seems like if you compare the electric system, gas system operating centers, you know, typically the gas is like a decade behind, although the new PG&E center may be even state-of-the-art, their gas dispatch center at this point seems to be a step ahead of the electric system, so as you start thinking about sensors SKADA, you know, basically information-based, again by bringing new technology into the gas operations side, and it's been many years ago I was in the El Paso

Control Center and, again, that was sort of fairly primitive at that stage, you'd have people go out and measure the meters once a day, once a month, or whatever, and they were moving towards the SKADA system where they'd even know what was flowing through some of the pipes. So again, if there's a way to move this more towards real time, that would be presumably something to think about. We work a lot with ARPA-E on R&D stuff, so again, I think a lot of our focus in this area is on the research, both climate research and also coming out of the San Bruno Safety Research, but trying to look at where we can help move the needle on the gas side and the R&D side, so that certainly -- when we go out, we ask for feedback on it, and often we just have the individual researchers coming in saying send me more money, so to the extent we have more of an EDF perspective on where the public good is, that would be very helpful to help us on the R&D side.

MR. O'CONNOR: Absolutely. And I think that the presentation earlier today talking about the projects that are out there, one note is that, as someone who has tried to follow the project submissions over the years, it's not obviously the most intuitively obvious section of the Commission’s website and processes, especially when there’s so many things that are happening in this area to fund methane detection, leak abatement, flyovers, and if there were an opportunity to increase the ability of the individual stakeholders to know kind of what’s on the table for potential funding by the Commission in possibly a new light, that could be very helpful for increasing participation in those requests.

CHAIRMAN WEISENMILLER: Now I was going to say, I don’t know if Mike is still here – oh, Laurie is there, so Laurie would love to talk to you about how to facilitate that sort of participation and feedback, right? Yes. We do a lot of outreach. Obviously one of our difficulties is not giving, you know, if individual researchers make sure they don’t have any advanced warning of where we’re heading, but at the same time trying to get sort of a policy direction on, yeah, we need better sensors, as opposed to the next six months from now we’re going to do a PON that covers blah blah blah amount of money in this very narrow topic, we have to sort of skate that. But we definitely are looking for ways.

I guess the other question generally, is that part -- and also certainly we're trying to do much more in sort of disadvantaged communities and the diversity aspects, so obviously as we go through trying to make sure that R&D dollars really capture the needs of all Californians, and not just at the sort of wealthy early adapters.

MR. O'CONNOR: Well, we could talk for a long while about the opportunity to focus benefits in disadvantaged communities. One project we did undertake in Texas was to involve and to outreach to local communities so that when they did experience, or see, or witness both from the communities, but also from the operators of individual facilities potential issues associated with emissions, or operational questions that might have the potential to result in localized emissions that they knew of, how they could both report that internally, but also externally, to provide for more rapid response. We've been seeing a fair bit of attention and focus on that from local communities to really give them more tools to be able to understand and to potentially interact with folks like yourselves at the Energy Commission and the Air Resources Board, to try to move the ball forward about sort of increased attention and focus by the facilities themselves on reducing emissions. A lot of this is going to, I think for the oil and gas operations, really be benefitted by very rigorous rule at the Air Resources Board that does require quarterly inspections, because we do think that that is going to get a very significant amount of the emissions from oil and gas operations and the attendant co-benefits that you get from managing the leakage from those operations.

CHAIRMAN WEISENMILLER: Yeah, well that certainly brings me to the question which I think you raised earlier, is a lot of our gas production is co-production of oil and so trying to understand that aspect of gas production, what needs to be done there.

MR. O'CONNOR: Uh-huh.

MR. MARXEN: Well, thank you, Mr. Chair and once again, thank you Timothy and Ramon, it's been a pleasure to have you here. This will conclude this panel. For those of you who are listening on the phone, remember there will be a public comment period at the end of the third panel today. And with that, I will turn the microphone over to Heather.

MS. RAITT: I think we're ready to take our lunch break. Does the Chair have anything to add?

CHAIRMAN WEISENMILLER: No, I think that would be good. I was going to say, the only thing I would say is if there's anyone in the room who, you know, doesn't plan to come back after lunch and who has a public comment, I certainly would welcome them to step up now.

MS. RAITT: I do think we have one person on WebEx who may have a comment, as well, if we want to go ahead and take that?

CHAIRMAN WEISENMILLER: Yeah. So now and then we'll do one at the end of the day, but certainly. If you're going to be at the end of the day, then certainly if you'll stick around for that, that would be good. But otherwise, go forward.

MS. RAITT: So I believe Rosa Dominguez is on the line and she had a question.

MS. DOMINGUEZ: Hello?

MS. RAITT: Yes, go ahead.

MS. DOMINGUEZ: Okay. Hi. I have a question for Ramon Alvarez and the question was that using his method of technology warming potential, it’s a little different to the traditional global warming potential method. And I was wondering if he -- and I see how his method has advantages because it’s a time dependent -- it gives you an idea of time dependent warming, but I was wondering if he has an idea of why IPCC is not using methods like this, or whether they’re considering incorporating it.

MR. ALVAREZ: Thank you for the question. This is Ramon Alvarez. You know, it’s a new idea and it’s a little bit complicated. It’s really not that much different than the 100-year or 20-year global warming potential. We think it’s a lot more insightful and it sort of removes that choice about which is the right one. I think what we’re looking at is that time dependence of the climate influence, so it shows you the whole story and, you know, you can derive from our work the conventional analysis you would get with using the 100-year or 20-year global warming potential. We probably need to do a better job of providing that grounding point for people so that they feel more comfortable that this is not just this complicated but not useful analysis. I'll mention that almost at the same time we published our new work on heavy-duty fuel switching, Carnegie Mellon published a paper on the same topic and actually independently calculating emissions and using 100-year and 20-year global warming potentials, they found similar results to ours, again, in fact theirs were a little bit worse, even, for the natural gas vehicles. They found that even at 100-year timeframe, there were still damages, and we're predicting between 50 to 90 is where you start to get climate benefits. So I think, you know, with some time and I think practice people will get more comfortable with this method, but I think you get 50-75 percent of the insight still with the 20-year global warming potential than the 100-year. It just tells you that there's a time element that needs to be -- that has points besides just those.

MS. DOMINGUEZ: Yeah, so one more question would be, how different do you think your results are from Carnegie Mellon's? Because if they project that even after 100 years is the worse and yours is it may be after 50 to 90 years, I think you said, is the difference in these conclusions due to the fact that Carnegie Mellon is estimating the cumulative warming?

MR. ALVAREZ: I need to look more carefully, and we just found out about this paper last week, at the source of the difference, but my guess is that it's some combination of the emissions of the gas supply chain, the emissions assumed for the vehicle, and the efficiency of the vehicle. Those are the three parameters that drive the results; otherwise, you just get whatever the CO_2 emissions are from combustion, and as we acknowledge in the paper, all three of those parameters have a lot of uncertainty associated with them, and there's not a lot of great data, so my guess is that we just differ a little bit on the emissions assumed.

MS. DOMINGUEZ: Okay, so for full disclosure, I am a Researcher at U.C. Davis and actually I also have a research paper on the carbon intensity that the CEC is funding therewith, and I was wondering maybe we can take this offline, but I was wondering if I can check back with you to make sure we have similar assumptions in all these parameters?

MR. ALVAREZ: Sure, yeah, please call me.

MS. DOMINGUEZ: Okay, thank you.

MS. RAITT: Thank you. And I don't think we have anyone else on the WebEx, so….

CHAIRMAN WEISENMILLER: Okay, so we'll take a break. We'll come back at 1:30?

MS. RAITT: Yes, 1:30.

(Break at 12:36 p.m.)

(Reconvene at 1:31 p.m.)

MS. RAITT: Okay, so we'll start again after our lunch break. And we have a panel this afternoon on California's Ongoing Research and Potential Detection and Mitigation Efforts, with the Moderator David Stoms. Go ahead, David.

MR. STOMS: Good afternoon. My name is David Stoms from the Energy Research and Development Division here at the Energy Commission. I'll be moderating this afternoon's final panel. And just as a kind of quick recap of where we are in the program, today's agenda, we started with perspectives from State agencies and then moved into a series of projects done by EDF on looking at emissions from different components of the natural gas system and kind of from various parts of the country. And this afternoon we're going to focus directly on California, both from the research side, research being done in California specifically, and then we'll also have a couple of utilities talk about work they're doing on both detection of emissions and reduction of emissions.

So our first speaker then is going to be the research part of the program, is Dr. Marc Fischer. He's a Staff Scientist in the Sustainable Energy Systems Group and Energy Technology area at Lawrence Berkeley National Lab. He's an Associate Researcher at the Air Quality Research Center at U.C. Davis, as well. Dr. Fischer's work focuses on quantifying and mitigating earth radiative forcing due to greenhouse gases and human habitation, and development and identifying sustainable solutions for energy-related environmental problems. Dr. Fischer received B.S., M.S. and PhD degrees in Physics from MIT, University of Illinois, and U.C. Berkeley, respectively. Dr. Fischer, and if you want to drive the slides yourself, or if you'd like to sit here, whichever you'd prefer.

DR. FISCHER: Good afternoon, Chair

Weisenmiller. Thank you for hearing me, thank you all for your attention. I'm going to give an overview of preliminary work that we've done to survey the methane emissions from the natural gas system in California from wells to meters.

I'll give a brief motivation and overview, which I think I can do pretty quickly because most of you are already intimately familiar with this problem, that will include the natural gas methane contribution to California as a climate pollutant, and some work on Bottom-up estimates of natural gas methane emissions.

I'll follow with a description of what we call the California Greenhouse Gas Emission Measurement, or CALGEM project, focusing on natural gas.

I'll say something about regional Top-down estimates of methane from the San Francisco Bay Area and sort of more generally the potential for Top-down studies at the regional scale, some airborne facility scale measurements that will allow one to say something about emissions from sort of kilometer scale facilities, a further fine grained approach using something called a localized mobile plume integration technique, and then at sort of the scale of individual residences, say something about some initial work we've done on residential buildings. Next slide.

First, I want to acknowledge the team of people that make this work possible. First, thank the Energy Commission and the Air Resources Board for their support in our large scale methane and other greenhouse gas measurements. This work here is primarily focused on natural gas and is supported by the Energy Commission's Natural Gas Program.

Beyond LBNL and U.C. Davis, we have collaborators pretty much across the U.C. system and at other institutions sort of within the state and nationally.

To give you a very broad brush overview of the problem, California's natural gas provides roughly half of California's fossil fuel energy. Methane is a short-lived climate pollutant. In a rough term, the strength of methane relative to CO_2 is such that, if three percent of natural gas were to leak to the atmosphere without being combusted in some process, the other 97 percent that is combusted to CO_2 would produce the same effective radiative forcing on a 20-year timescale. In other words, methane is incredibly potent on a short time scale, and so getting a handle on it is clearly something that we should be considering as part of overall climate protection.

In the past, pre-meter distribution and post-meter consumption leakage paths hadn't been addressed very in great detail, and that's something that we're trying to bring into the work in this case. California is now moving forward on efforts to control emissions and, while natural gas is a small part of total methane emissions, at least in our current estimates, it certainly deserves attention being from sort of a primary use sector of the energy economy.

To give you an overview of the natural gas system, the sectors run as you're all I think familiar, this is a slide that Guido and his team have prepared, taking U.S. EPA sort of representation of production, processing, transmission and distribution, and adding to it these downstream sectors which arguably may contribute in some significant way on the consumption side, and I'm going to use the word "consumption" from now on rather than distribution to distinguish it from the distribution system.

Our initial work on natural gas has focused on essentially a first guess or first estimate of Bottom-up emissions across all of those sectors from production to consumption, and it has been driven by U.S. EPA emission factors and GIS activity data throughout the state where it's available. It includes production from both conventional and enhanced recovery wells, transmission compression and storage, distribution we handled -- and I really should have said on this slide -- distribution and consumption, assuming that the emissions in that at least currently poorly understood set of sectors is roughly a third of a percent of the regional consumption. And this is really essentially what I would call a first guess.

We put this together and published it in the ES&T, the comparison of this Bottom-up, with more fine grain Top-down work from the Los Angeles Basin suggests that this may be an underestimate for the Los Angeles Basin, but there are still I think important remaining questions there, so it's certainly not a final word. Bottom line, we estimate at this point that natural gas emissions are likely on order of 200 to 400 gigagrams of methane a year. My apologies for mass units. Putting this in perspective, livestock and landfills are a much larger source so that natural gas might be only 10 or 20 percent of total methane.

So to go beyond the Bottom-up, we've conducted and are still conducting a series of different related studies at different effectively spatial scales and temporal scales. Regional emissions largely done through collaborating tower networks, and ARB has been instrumental in putting together a large set of towers, there's other groups now, the Los Angeles Megacities Project has a bunch of towers running there, and we have a few towers within California.

We've also tried to look at individual facilities and I'll show you some of that work using aircraft observations, and then more recently we've started to look at essentially small scale sources within either urban environments, or individual gas wells using a mobile plume integration method that I'll tell you about, and then a little bit of work on buildings that's just starting and is going to expand, as was mentioned by Guido earlier.

So in terms of estimating regional emissions, as I said before, natural gas is only a small part of the total methane budget of California and so at the regional scale there is a real challenge in attributing methane in the atmosphere at the regional scale to methane emitted by natural gas, as opposed to landfills and livestock. And to do that, it's really essential to use additional tracers that are specific, as much as possible, to natural gas, and ethane is a key discriminant there, additional Alkanes and other species are also important. What these maps here show are essentially on the bottom left natural gas methane, in the middle using the same color scale, total methane. And so you can see that only in the urban areas is natural gas and the Southern San Joaquin Valley, natural gas is estimated to be a big part of the total.

In the Bay Area, we have started doing some work in collaboration with the Bay Area

Quality Management District and PG&E. The result of the most recent work has been published by Farley et al and ES&T. That work suggests that methane emissions based on a correlation with CO as a relatively comparatively well-known tracer, are roughly 1-1/2 to two times the current Bay Area Air Quality Management District inventory for methane emissions, suggesting that there are sources of methane that are either underestimated or not accounted for in their current inventory. And we're working with Bay Area now to resolve those differences and try to identify where the sources are. Really, as I mentioned before and want to emphasize again, there is no substitute for being able to attribute methane to natural gas as distinct from the other sources which are comparatively large, and additional tracers are a key to that. Next slide, please.

So to try to get a better handle on sources with spatial distributions that are sufficiently small that one can sample them unambiguously as a natural gas source, we've been in our CALGEM-NG project subtracting to Scientific Aviation and in the bottom left you see a photograph of Steve Conley's airplane.

Steve has instrumented the plane -- Steve did his PhD at U.C. Davis in Chemistry, he's a Navy man and he's instrumented a small plane with a rack of gas instruments, a very high performance anemometer and associated instrumentation, and simultaneously keeps himself alive while he's flying and collects great data.

What this figure shows on the right is a map of methane collected from the plane upwind, sort of the upper left of that plot, and downwind, lower right, showing that the methane on the downwind side of a known source is very clearly measurable as compared with the upwind side, the differences unmistakably detectable and easy to quantify in this case, by integrating multiple loops at different altitudes you can effectively form what amounts to a cylinder of measurement around a given facility and estimate the total emissions. And when Steve does this for known sources, the agreement is now at the sort of 20 percent uncertainty level. I think this will vary with weather conditions, but in the cases that he has tested with known sources, he has been very successful. And I would just comment that Steve thought ahead and, working with CEC and PG&E, instrumented the plane with ethane measurements, as well, so that one can measure the ratio of methane to ethane and very narrowly attribute sources not only with their spatial signature, but with a gas signature.

So what we've done so far working with Steve is to fly loops around cylinders around different facilities in the Bay Area and sort of Central California area, these have included so far natural gas storage and petroleum refining, we're also looking at other sources. But these have been the ones that are clearly identified spatially and were straightforward to fly, although we've had some interesting interactions recently on that. In sort of round numbers, the U.S. EPA estimates that Bottom-up emissions for a typical storage facility might be on the order of 80 kilograms of methane per hour and in our flights we've seen quite variable -- I will not say variable, I will say flying five or six different storage facilities in the sort of Central California area, we've seen two sites with non-detection; in other words, we could not see a significant source, one with a small sort of 11 kilogram an hour leak rate, and then over five different flight days at one particular site, measured between 80 and 300 kilograms an hour. So appears that at least for the site where there were quite large and measurable emissions, they were also variable.

We have measured the ethane to methane ratio for that large facility and found that it agreed with what we would expect based on pubic reporting of PG&E's methane to ethane ratios. And we feel confident that this is a solid natural gas signature.

This is not associated with natural gas, but it's not pure natural gas infrastructure, sort of associated industry, we've looked at three refineries this spring from February and May, and found that the emissions from those refineries were both large and variable. We are in the process of studying that further, here the ethane to methane ratios varied quite a bit, and we're guessing that this has to do with different processes occurring at the plants.

In terms of production, we have gone to the Southern San Joaquin and attempted many flight hours with often very limited success due to weather, but for one particular field on the west side of the San Joaquin Valley, we were able to measure very clearly an upwind, downwind enhancement in that figure, and the lower right shows blue toward the upwind side and sort of reds and yellows on the downwind side indicating methane enhancements. When we integrate that up, we found integrated emissions extrapolated to an annual basis that were on order 15 gigagrams of methane per year, roughly consistent with our CALGEM-NG Bottom-up inventory estimate based on the wells that are there.

So, I mean, this is really just a first step. I think other groups are measuring these fields at other times, the data needs to be pulled together into a larger hole to get a picture because it does appear quite episodic.

Next, going to finer scales, we've built an instrument in collaboration with Picarro. Picarro is a manufacturer of high quality greenhouse gas analyzers and with Picarro we've built an instrument which we call the mobile plume integrator, and really what this is is a set of gas analyzers and a car with a mast on it, and as it drives through plumes, it measures their vertical distribution and their horizontal distribution. And by measuring simultaneously the wind velocity, one can construct a mass balance estimate of the methane crossing the path of the car, and from that make an estimate of the emissions. When we've tested this technology in controlled situation with a known leak rate, and we've done this both on our own in Berkeley and through partnership with PG&E at their test facility, we find that the estimated emissions are good to about 30 percent in typical conditions when the plume is completely captured by the height of the mast. And that is not always the case, but we can very straightforwardly tell when that is not the case, and then our estimate is really a lower limit on emissions as opposed to a quantified number.

I want to emphasize that this type of technology provides the kind of tool that you can make quantitative estimates with, it is not a relatively leak rate, or relative enhancement method, it is a quantitative emissions measurement. We have submitted a patent on this technology and we are waiting to see if LBL follows through with the patent.

In terms of capped gas wells, people

brought this up as an interesting question, we've started to look at that. On the upper right you see a picture of the mobile plume integrator system with the plucky experimenter standing next to it. You can see the masts sticking up as sort of a while pole on the front of the ancient Prius, and what we did was using DOGGR's well maps, found a bunch of capped and idle wells and spent a day driving by as many of them as we could approach from public roads. We looked at 12 capped wells. We were able to quantify one plume very clearly, here I'm going to switch to Volume Units and here the leak rates were on order of 100 ccs a minute, or a tenth of a liter a minute. Three other plumes were measured with smaller, well, some smaller, some larger leaks, but we only got one pass on each of those, and then there were several that we either didn't get a detection on, or could not get downwind of. So in the lower right you can see a picture of a plume enhancement for one of the sources that we were actually able to drive all the way around, so you can clearly see the big downwind spike on the sort of upper portion of the plot.

We've now applied this technique to the

Bakersfield area, driving a series of roads through the Bakersfield Metropolitan Area, we detected 20 large leaks and, you know, numerous smaller ones, I guess I would comment here that Bakersfield was sufficiently rich in methane on average that smaller plumes that we could see in cleaner environments may have been masked here, so this really represents a lower limit. We found 40 percent of the emissions within half a kilometer of large distribution pipes and some of the largest emissions from an individual plume appeared to be closely co-located with distribution pipes that we found in maps later.

The integrated leaks along our path of driving were about six kilograms of methane an hour, and scaling by area that would be equivalent to about 90 kilograms of methane per hour from the sort of Becker Field Metropolitan Area, which was roughly consistent with our estimate of about 0.3 percent of consumption being leaked in the distribution system -- sorry, distribution and consumption side, distribution pipes not being the same thing as post-meter leakage.

Finally, in order to get at post-meter

leakage, we've started looking at leakage from residential structures and we're starting there because the commercial and industrial sectors are sort of outside of our ability to readily sample at this point. We've done an initially study of houses in essentially the Berkeley and Oakland San Francisco Area that we had private access to, and here we depressurized the house slightly and then measured the enhancement of methane in that exhaust flow air relative to the inflow air, and through a mass balance estimate emissions. The end result of this work is that from the 10 houses we've studied so far, we have an average leak rate of about 7 ccs a minute, which for the houses we were able to compare with, was equivalent to about 0.16 percent of their consumption. And I guess I will comment that, in terms of attribution, we used the C13 signature of the methane that we observed to see that it was in fact consistent with natural gas as opposed to a biogenic course. I could say more about that if people are interested.

We're now starting a project for CEC to measure 50 to 75 homes across California's housing stock and I'll be able to tell you more about that in, I would guess, about a year.

Sort of adding on to the residential leakage picture, the tests that we did with the blower doors were done with the buildings in what we would call a quiescent state, none of their gas appliances were under active operation, they might have had pilot lights lit, but they did not have any of their sort of large burners running. And we've started to look now at the large burners on several different types of appliances and we've done this using a combination of mass balance and essentially looking at the ratio of methane to CO_2 enhancements, and with the fuel use of the device able to say something about the methane emissions. We find that, in particular, tankless water heaters which have very small high intensity burners emit a fair amount of methane and we've look at now three of them, and their emissions have ranged from 80 to 300 ccs a minute of methane, which in one hour of operation would be roughly equivalent to the average house leakage. So it appears that they are a non-trivial potential addition to methane emissions and should be considered further.

We've also looked at a couple of clothes dryers that emitted a small amount of methane, one gas range which emitted a small amount of methane, and we looked at a couple of high efficiency error heaters, furnaces. And the furnaces very pleasingly and surprisingly actually consume the atmospheric methane, so the outflow from the combustions process actually has removed methane. Next slide, please.

In summary, the work sponsored by CEC is identifying key components of natural gas methane emissions from the California system. The emissions from production and distribution sectors are uncertain and likely underestimated in the state inventories that is our current estimate. However, production emissions are extremely episodic in our experience. I didn’t show slides of this, but some work over an oil and gas field changed radically with weather, there were drilling platforms in clear operation, and so I think this is probably consistent with some of the work, the much larger body of work that’s being done nationally, indicating that some care if needed in collecting what I would say true time averaged data, or a very very careful program of being onsite when different operations that might admit methane are operating.

Distribution emissions are diffuse and natural gas tracers are essential for making a clear attribution, but in summary, atmospheric measurements can be used to quantify emissions and in particularly should be capable of monitoring reductions in emissions at multiple scales. Thank you.

CHAIRMAN WEISENMILLER: So a couple questions. One of them is what is the tradeoff between using the Isotopic ratios or using ethane for the attribution?

DR. FISCHER: Yeah, that's a good question. I guess the glib response would be, since there are almost no sources other than oil and gas producing ethane, it is a pretty -- ethane is a pretty strongly indicative tracer; whereas the isotope ratios vary significantly across both biogenic sources and fossil fuel sources, the ethane is likely to be a tighter tracer. But I would say more generally multiple techniques should always be considered to the extent that it's economically feasible.

CHAIRMAN WEISENMILLER: Did you do any

mapping at all of biogenic or, as you were doing the routes, I mean, were you seeing concentrations?

DR. FISCHER: That's a good question. I guess I would say we have not had the resource to focus on the narrowing in on biogenic sources as part of our work. In separate work for ARB where we're responsible for estimating total methane emissions from all sources, and attributing regional emissions with VOC tracers, we're starting to make a handle on that and, you know, the evidence that's available now strongly suggests that the bottom up maps at least in rough measure are accurate in portraying a picture where biogenic sources vastly outweigh fossil for methane.

CHAIRMAN WEISENMILLER: Okay. Yeah, and I guess the last one I'm trying to figure out, we heard this morning about the risk profile on -- this may be more for PG&E and SoCal -- but in terms of different levels of risk of emissions, you know, 1, 2, 3, and I wasn't sure if you could map from your stuff to that sort of size of the leak and get to the risk? Say in Bakersfield or --?

DR. FISCHER: I apologize that I am not familiar with the risk categorization metric well enough to do that quickly.

CHAIRMAN WEISENMILLER: Okay, that's fine. Again, my guess was more a fair question for the utilities. Great, thank you.

MR. STOMS: Thank you, Marc. Our next speaker is Francois Rongere. He's currently managing research and development and innovation for PG&E gas operations. In this role, his team is responsible for the detection, assessment, adaptation, and introduction of new technologies in the business. He has previously worked for PG&E's Energy Efficiency Department, focusing on the industry, high tech, bio tech, and healthcare sectors. In 2000, he established Easenergy Inc., detecting and partnering with start-up companies of the energy sector. Besides, he has been teaching a class about Renewable Energy at San Jose State since 2007. He is a graduate of the Institute National PoliTechnique De Grenoble in France. Francois.

MR. RONGERE: Thank you very much, David. So can you pass the slides for me? Perfect. Perhaps I can answer your question first about how to characterize the characteristic of a leak based on flow rate measurement. The grade of the leaks from Grade 1, which is the other leaks to the Grade 3 take into account the position of the leak more than actually the size of the leak. So a measurement of the flow rate doesn't correlate very well with the grade of the leak.

So just my presentation, I will give you an opportunity to give you a sense of what PG&E is, but will also present some of the actions we have taken in order to reduce leak and methane emissions. And then I will switch to my part, which is more R&D and talking about technology we are working on in order to improve leak detection, mainly, and leak quantification.

So PG&E is on this map the northern part of California, about 5,800 miles of transmission, pipelines, and 42,000 miles of distribution pipelines. We serve about 4.3 million customers, about 50 million person people and we deliver about trillion cubic feet of natural gas per year.

So starting with the action we take on methane emission abatement, so I just listed here to give you a sense of what we have done in the past years about it. So first we talk about it, replacement of the bleeding controllers with our low bleeding controllers, this is true for compressor stations and for regulation stations. Second, we ordered our compressor sequencing in order to put so most emitting during their shutoff process, so the largest blowdown in their shutdown process compressors, as baseloads, that we actually decrease the emissions right away. The third point, we do cross compression as often as possible when we do idle testing, we have to empty the gas to replace the gas water when we do idle tests, to purge the gas we can use another pipeline if it's close by and by cross compression we avoid to release this gas into the atmosphere.

Fourth point is to modify the Centrifugal compressors, we have to dry gas seals. There was wet gas seals and more leaking than dry glass seals, so it's just an improved technology that allows us to reduce the emission from our compressors. Also, the starters of the compressors are an opportunity to move from gas powered starters to air or electric starters, and so that reduces naturally the emissions.

We also have used the most advanced technology to detect leaks, you know, distribution systems, and we include that in a new process we call Super Crew, you know, that you more holistically take into account the leak detection and repair process, and this actually led to a reduction of about one-third of the Grade 3 leaks. And that's, I think, we talk about these grade leaks, grade 3 leaks which can be fairly large and stay for a long time and I think that using this approach which is more integrated management approach, purely safety leak management, so it's more integrated in the overall safety plan of our company, we have been able to take care of the Grade 3 leaks when marginally it's not too much cost and we get the better results. So I think that integration, you know, integration management plan is a key in order to optimize the management of the Grade 3 leaks.

Also, one thing is we finished last year at the end of 2014, we have actually retired our last cast iron pipeline from the system, so we don't have any cast iron pipeline anymore in our system. And cast iron pipeline are one of the large of methane emissions, so it's a good way also to reduce methane emissions.

So that's it about the action we have taken to reduce methane emissions, but moving forward we want to also to continue to improve and I will just give you some examples of the products we have. And it's not PG&E alone, we see that that's actually connect to many of the projects we have talked about, we are working extensively in collaboration, either in California with the California Energy Commission, but also at the national level we have a three group of R&D co-funding with the other gas operators and utilities. These three groups are PRCI Pipeline Research Council International, which is focusing more on transmission pipeline and compressor stations. In partnership with NYSearch, which means New York Search, but actually now is nationwide and SoCal and us are members of NYSearch and it's focusing more on distribution systems. The last but not least group we belong to is GTI Gas Technology Institute in Chicago. So these projects actually are in collaboration with these different organizations and that's very important for us.

We want to share the effort and the results of this R&D.

So one thing that has not been mentioned this morning is a project funded by the California Energy Commission, co-funded with PG&E, about two or three years ago through the Small Grant Process. And with Ease and PSI technology company, the idea was to develop a continuous monitoring system for leak detection, so the technology itself is a relatively well known technology, it is an RMLD detector which is used by the utilities to locate leaks from distance, so you have a laser beam that you point to where you think the leak is, and the absorption of the light through this beam will tell you how much methane is between you and the target. So the idea is to put this technology on a pole and to continuously monitor a line of sight and we have demonstrated that we can go up to 500 feet, but we are just limited by the size of our field, the idea is it can go further than 1,000 feet. The idea is, by the system you can put a longer pipeline, you can monitor this pipeline or the facility which emits methane and continuously monitor the emission of methane.

The project has been completed at the end of 2013, and the technologies are available now.

So the solar panel actually fed the electricity on the equipment and the equipment is totally anonymous, and you can take the communication using your Verizon card, can transfer the information to the control room easily.

Another technology that we have developed, this time with PSI, the first group I mentioned about, and also with JPL in Pasadena, is an handheld methane detector which is able now to detect at the level of ppbs of methane. So what a technology like Picarro, others have brought, is this ability to detect very low level of methane which allows us to detect the leaks than the traditional equipment. This technology, which has been developed by JPL to find methane en masse by definition had to be very light and small, so we take advantage of that in other to have a tool which can be easily carried around to measure methane. And associated with very cool based methane detection, for example, we can accelerate the process of finding the leak. As a car in the street measures the methane in the street, after that you have to find the leak and to grade the leak, and this tool actually makes this connection to find the actual leak.

An evolution of that, so the project has been done with PSI last year, now we are moving to continue to leverage the low weight and size of the tool to mount that on a UAV, and using a UAV we can survey facilities like regulation station or pipelines or compressor stations easily, and measure the methane, and obtain a map of methane, a little bit of what Marc mentioned before, but with a UAV on the smaller scale than an aircraft. So that's another project which is led by NYSearch with U.C. Merced and JPL.

So this technology focused mainly on detection, but we can actually extend the capabilities to go to methane quantification, even if its' not the same problem, and the technology which are done generally for detection needs to be adapted for methane quantification, it's not the same problem at all. So some of the things we are doing, again with NYSearch, it's a project we have started and our friends of EDF are a member of that consortium around this project, participating advisor of the projects, testing different technologies to quantify leaks from the distribution systems. And what we are looking for is a way to quantify these leaks fairly rapidly because if we need too much time to quantify the leaks, of course, economically it is not viable, so we want to detect technologies that can help us to do that more rapidly. So it's a project that started just at the end of 2014, we are just in the middle of it, we have done a series of control tests using actually the training facility of UGG on the East Coast, very similar to our training facility in Livermore, and so we have selected initially three technologies and we are testing them now. And we move to a field test after these first control tests are completed.

Here is a more I would say exploratory project, again with NYSearch, to develop a technology which will really focus on the quantification of measuring the flow rate because we are measuring concentration in general with the tools we are using, and we aim fair from the concentration the floor rate. If we can measure directly the speed field, we can actually have a good representation of the flow rate, and that's what we tried to do with this super gas-emitting technologies, that SR International has developed, and we apply it to small methane leaks now. Fairly exploratory, I would not say we would get a system working at the end of the year, it will take several years to put that in place and to test it, but it’s really a new look at quantification of methane emissions by trying to measure directly the flow rate.

So Marc mentioned this project with the Bay Area Air Quality Management District. We don’t fund it but we are happy to be part of it, and to support the work done by Lawrence Berkeley Laboratory. And we really expect to learn from that, especially about the distribution of the leaks and the distribution of the methane emissions; we know where the leaks are, but the distribution of the methane emissions in the geographic area and to try to correlate that with our leaks that we find. So we’re very excited about this project.

Another project I wanted to mention that we support as well, by doing some gas release from our system for them, so it’s a project from NASA JPL which also aims to quantify large methane emitters by combining two technologies, one which is mapping of relatively large scale concentration of methane, you know, to try to develop a sort of control volume of the system and count in and out of this control volume. And also the HYTES system which is more direct measurement of concentration using a passive low frequency infrared system which observes the emissions from the ground and in very low wavelengths and it measures the methane in that emissions, so different technologies that actually we use generally. And it's interesting to work with them on that and, same thing, we partner with them in order to help them to improve that technology and to learn about these technologies.

Marc mentioned it, is the work done by Steve Connolly and Ian Faloona about aircraft-based characterization of methane emission, and we participate through some control ways, as well from our system where they can calibrate our system, it's very important and we are so excited by the progress they are making on that.

I think we are done. Thank you very much for your attention and I would be happy to answer any question you may have.

CHAIRMAN WEISENMILLER: Great. Thank you. Just a few. So first, do you know, who owns what used to be PG&E's gathering system?

MR. RONGERE: I don't know.

CHAIRMAN WEISENMILLER: I noticed it wasn't listed on the PG&E facility, you got rid of it, okay. In terms of hydrotesting, any idea of how much you may be able to control versus not control in terms of the gas part?

MR. RONGERE: I don't have the number. I know that we try as often as we can, but I don't have a comparison of how much we have avoided compared to how much we have released to the atmosphere. We can measure that.

CHAIRMAN WEISENMILLER: Okay, that would be good. I was trying to understand is, you know, PG&E is unusual in that with the Henschall exemption, you basically have gas transmission systems which are not regulated by FERC, so trying to understand at least in this area the difference between PUC and FERC Regulation, in terms of your backbone system, in terms of greenhouse gas emissions.

MR. RONGERE: FERC, I think, doesn't

regulate the gas emission of the systems, so I'm not sure about this question, but perhaps somebody else has a better answer than I can have.

CHAIRMAN WEISENMILLER: Yeah, I think earlier it was asked as sort of -- the comment on the FERC proposed Regulations, and so I was trying to understand how they might compare to the PUC's -- you know, California is unusual to have what most of the country would have is FERC regulated pipelines. We do have some in terms of Mojave and Kern River, but for the PG&E backbone and SoCal Gas backbones, they are regulated by the PUC and not by FERC. So anyway, we can line that up at some stage.

MR. RONGERE: I will find an answer for you.

CHAIRMAN WEISENMILLER: Okay, that would be great. Thanks.

MR. RONGERE: Thank you.

MR. STOMS: Thank you, Francois. Our final speaker today is Deanna Haines. She has worked in the Utilities Sector since 1988 and has held various leadership positions primarily in the Engineering and Environmental areas. Deanna currently is Director of Gas Engineering for Sempra Energy's California Utilities, Southern California Gas Company, and San Diego Gas and Electric.

As Director of Gas Engineering, Ms. Haines oversees the engineering standards and research programs related to the design, operation, and construction of the gas infrastructure to ensure the reliable and safe operation of the system. She has a Master's degree in Business Administration from University of Redlands and a Bachelor's Degree in Chemical Engineering from USC. Deanna.

MS. HAINES: Thank you. Hopefully, well, I think you saved the best for last here, yeah. I'm surprised that people are still awake, you know, it's that time after lunch, but hopefully nobody will fall asleep.

I'm going to just quickly talk about the company background, what we've done in the past in terms of methane reductions. Francois covered a lot of the technology issues, so I'm not going to go too much in depth on that. Essentially what Francois said is pretty much what we're doing also. So the technology, I think Francois did a great job of covering that.

And then I'm going to talk about our vision of our system and how we use our pipeline system, it's going to be part of I think the overall solution of the methane issue. So next.

So our system is the biggest and baddest and most bionic in the nation, it's the largest. We've been in business over 140 years. We cover essentially the bottom half of the state between San Diego Gas & Electric and Southern California Gas Company. We have about 21 million customers and nearly six million meters.

From an operational standpoint, we deliver about a trillion cubic feet of gas a year, which represents about five percent of the U.S. deliveries, and we have about 136 billion cubic feet of storage capacity. Our backbone transmission system is about 3,700 miles. We have a distribution network which is extensive, about 58,000 or nearly 58,000 of mains and 55,000 or 55.5 thousand of services. Our distribution system operates at about 60 pounds. And I want to talk a little bit about the seasonality issue that was brought up around that. Because our system is regulated down to a certain pressure and leaks are dependent upon pressure, you could pretty much, even with the winter or summer, we're pretty much maintaining a 60-pound system for the distribution network, and you get more withdraw on the system during the winter, so it probably is actually lower than 60 pounds during the winter. I would say it doesn't fluctuate enough to make much of a difference in terms of seasonality on the distribution system because of the maintaining of the constant pressure, essentially. My anecdotal thoughts on that. We have about 1,900 Regulator stations.

So in terms of how we manage our methane and we really do try to collaborate with our Regulators and especially the CPUC, working with them to cost-effectively reduce our methane to get the synergies between the safety aspects and the coincidental environmental benefits. We have right now a general rate case before the Commission where we've asked them to accelerate some of the replacement of the pipe that we know needs to be replaced, such as the aldyl-AA, and we have asked for also to help go after those Code 3, those Grade 3 leaks, and to eliminate that carryover every year because we don't have the resources right now to go after all the leaks. So we are asking to eliminate that so that we don't carry those over every year by the year 2018. So we've got that under the Commission right now and we're hoping that we'll get the money to go after those.

We also are funding a lot of research, development and demonstration programs and Francois went over a lot of those, and I'll touch base on a few of those.

Because of the Pipeline Safety Enhancement Project that we've got underway, we're investing about a billion and a half dollars in upgrading our system, hydrostatic testing, but also replacing pipe. And we also are expanding our pipeline information management system, which I'll go a little bit more into.

We do a lot of partnering. We were part of the distribution study with the Environmental Defense Fund. We are part of the mapping study that they talked about earlier. We have worked with the California Energy Commission, California Air Resources Board, Gas Technology Institute, we are very active in helping figure out what the answers are using science-based approaches.

We were part of the original EPA Natural Gas STAR Program, we were one of the first members to join that back in the early '90s, and we institute a lot of the best management practices, what we're talking about today, and what Francois talked about. And just in the last five years, those best management practices such as eliminating high bleed pneumatics in our meters and Reg stations to lower bleed or no bleed, has eliminated about 360,000 metric tons of CO_2 equivalent. So we're doing that and we've done it for years, and one of the things we did 20 years ago is eliminate the cast iron pipe in our system. So that's been out of our system for a while. We do have about half of our system is plastic, polyethylene plastic, we do have about 16 percent of unprotected still that we need to go after, and the rest is protected, too.

We do have some new studies that do show lower leak rates and it's primarily due to that system of modernization I talked about. EDF covered off a little bit on this when they talked about the Washington State University study. When we reported our emissions under AB 32 to CARB and to EPA, we report using these 20-plus-year-old emission factors. Washington State's study was able to go out and look at 13 different cities across the nation and our system was part of that study and the results show significantly lower emissions from the distribution system. A lot of the meter and rec stations have been upgraded, you know, since 20 years ago. And a lot of the – there's been a lot of modernization in terms of pipe replacement. Like I said, we've replaced our cast iron system.

There is still a lot that we need to do and the recent submittal of our 1371 Report, we have top 10 emitters that I will go through in a minute, and I'll talk about what we want to do with those. But if you just substitute those new emission factors for those two major categories of potential leaks, the underground pipeline leaks, and the meter and rec station, you get down to a system-wide emission rate of about .12 percent, and that seems to be a common theme. We're seeing that in our own internal engineering studies and in 1371 that we just submitted, that roughly about .12 percent is what we lose to the atmosphere.

And what we've found is that, in the 1371 data, that two-thirds of that is unintentional, you know, leaks, things like that, and about a third of it is related to our actual system operation, you know, maintenance, blowdowns and purging.

The extent of hydro-testing that we're doing, the purging that we have to do for pigging in the Pipeline Safety Improvement Act, that amounts to about I'd say six percent of that number.

The dig-ins to our system is about eight percent on average, and those are areas that we know we need to go after to eliminate dig-ins, that's a big area that we really want to go after because it's not only disruptive from an environmental standpoint, it's disruptive from a safety standpoint, too.

Picarro has been a key technology that we've been evaluating from a methane detection. We've been using Picarro mainly in the high risk areas where we have the adyl-A or we think we have adyl-A pipe, we've been using it as a screening tool to see if there's any excessive leakage that's going on in those areas. We consider it part of our portfolio of tools to help manage the risk on the system, and so we're looking at it as a good tool for us and also we're looking at it in terms of the quantification aspects that Francois talked about. And there's other things we're looking at, just our normal technology that we use to go out and find the leaks on the system. There's technologies that we can maybe correlate the percent gas that we're finding to possible quantification technology. So there may be some simple very straightforward things that we can integrate right into the work process and not have to get too crazy on this fun new technology that we're looking at.

The aerial surveys, you know, Francois touched base about that. We're doing some research on that using NYSEARCH which is a common group that we use for helping us partner on research projects.

We do have a technology plan that we submitted as part of our pipeline safety enhancement program that expands our use of methane detectors and I'll talk about that a little bit more, about where we'd want to put them. There's still a lot of what I would call more research that needs to be done to get the detectors down to lower detection levels and make it so that it’s more commercially available, like a smoke alarm or a carbon monoxide alarm. We’re also looking at fiber optic cabling along our high pressure mainly pipelines, and for right of way intrusion, that’s a key area in terms of the damage to our pipelines. And we’re looking at expanding our pipeline information management system and our radio systems to collect some more data.

So this is kind of the vision of it. The 2,100 methane detectors, we have committed to try to put those near hospitals, sensitive areas where folks may have problems evacuating. We’re looking at acoustic technologies in terms of hearing the pipeline and hearing a leak. We’re looking at adding more cathodic protection sensors, things like that, so we know if something has gone out of compliance with our cathodic protection. So just adding a lot more pipeline information data that we could bring in and start doing analytics on that data.

I think the most exciting thing for us is that we’re rolling out on the gas side our advanced meter program. You know, this has been out on the electric side for a while, but from the gas side, this is fairly new to us. And we've got nearly six million meters that are going to be able to get hourly data downloaded twice a day, I guess we're the only utility that has that ability to download it twice a day. And we're actually looking at analytics right now to be able to look for patterns in that data. At first we were just looking at it in terms of billing, you know, because most people don't want to get an excessive bill at the end of the month; well, now we can catch excessive consumption whether somebody left their barbecue on, or if there's an actual leak, you can see it in the pattern, in the consumption data.

We did some testing on about 50,000 residences where they had closed the account, you know, because they were moving, and everything should be shut off, and we found just a couple leaks off of that, but what was really surprising is we found water leaks on the water heater. So there was excessive consumption of gas trying to heat the new water that's coming in. And so it didn't matter what was heating the water, you just got excessive consumption and the water was leaking out. So that was very interesting.

We're also looking at connecting sensors within the home, carbon monoxide sensors, smoke alarms, and methane sensors if we could get the cost down to a consumer level, to our advanced meter network, and throwing that data into the advanced meter network and offering it back to the consumer so they can check, you know, besides just looking at consumption data. I think this is very promising because it gives you good instantaneous data and the consumer can get alarms and things like that, so there's a lot of good technology that's going on in terms of, you know, after the meter, or on the meter type of emissions.

We have developed some advanced tools to look inside the pipeline, you know, we've done a lot of things around the high pressure pipelines, the steel pipelines, but we haven't really addressed the smaller diameter pipelines and we haven't addressed, I think, some type of continuous monitoring, in situ monitoring of the plastic pipelines. Something that is kind of like your iRobot vacuum cleaner at home, you know, that stays inside the pipe, it's maybe nanoscale and it goes around and looks and tries to see the integrity, then goes back and checks in at some rechargeable spot, and then maybe uploads the signal to the advanced meter network. So that's kind of my vision, I've put that out to ARPA in the conference a couple weeks ago, and to who is going to come out with that next technology. I'd like to find the leak before it happens. I'd like to know the integrity of the system before it happens. And I think we're going to be there sooner than later.

One of the issues that keeps coming up is about how you differentiate the methane that's coming from these Top-down studies and Bottom-up studies, and Los Angeles, you know, I've been in this area for 20 years trying to differentiate our leaks versus natural seepages for a while, and what I've learned is that there's really only two real indicators of natural gas from our system, and that's our odorant. We have two types of odorant that we use, it's called tertiary butyl mercaptin and tetra hydrothiophane, and those are really the only signature tracer gases that are specific to our system. Most of the methane that we see, a lot of it is natural, it could be natural petrogenic, and natural biogenic. And as we start adding new sources, hopefully renewable biogas, onto our system, the isotopic ratio is not going to really help us and we're really going to have to rely on something like our odorant that is very specific to natural gas, and making sure people can smell our product. So that's something that's a real challenge I think for us as an industry.

So what we've learned is that the methane emissions from our distribution sector have been going down, they have been declining, and it's really due to infrastructure modernization. We do need to eliminate our backlogs, our carryovers of grade 3. We estimate based on our 1371 data that if we eliminate that carryover every year, we could probably reduce about 16 percent of the emissions. So that's something we really want to go for, and stop having these backlogs, have enough resources, and eventually integrate quantification technologies into the process so that we could prioritize based on the quantification.

We do want to accelerate our pipe

replacements. You know, we know generally speaking where our vulnerabilities are and the type of pipe that we have in the ground, unprotected steel, we want to get it either protected or replace it. The adyl-A we want to make sure it's not leaking, and if it has a history of leaks, we want to replace it. So we know where our vulnerabilities are, we have extensive risk management programs around the integrity of our system, and we want to accelerate that, those programs.

We continue to want to partner to make sure that we're finding the right issues and that we're not wasting our resources on non-issues, essentially, and we are very active in being part of the solution on this issue as Dr. Fischer mentioned, you know, methane is coming from all different sources, unfortunately a lot of it is coming from natural biogenic sources and agriculture and waste, and we want to go after that and we think we can.

Science-based approaches is what drives us in terms of our decisions and then, of course, the direct measurement study that came out from Washington State University, I think, is a very good study, it’s the most comprehensive that we’ve had, and it doubles the amount of samples to reduce uncertainty, you get more samples, that’s one of the key things you do, and they’ve doubled it. They’ve taken into account using Monte Carlo statistical analysis that uncertainty that we talked about. So I think the numbers are really well done and very well researched. And I think we need to rely on that as a good study that’s solid, that helps us point to the right areas to focus in on. Next slide.

This is just a repeat, we know that roughly about 80-85 percent of the methane is coming from the landfills, the wastewater, the cows, the farms, so we want to really go after that.

Our system is basically a pipeline system that can go over that, you know, we can take that anaerobic digester gas and move it into our system, make it pipeline quality, and if we’re using it for transportation, it’s a negative carbon intensity. I mean, this is a huge opportunity for us.

We do have some partnerships with Scripps on looking even at the combustion source of carbon dioxide, NO_x, and using algae to reduce that and make it back into biomethane. Next.

We're looking at our system as a way to store renewable energy. When the wind doesn't blow, the sun doesn't shine, what happens? You know, what do we do with that gap? And if we don't have the demand for the electricity during when the wind blows, what do we do with that excess electricity? So Germany has figured that out and they have a concept called the Power to Gas Concept, where they take that excess electricity and they use electrolysis to split the water and make it into hydrogen and oxygen, and use that hydrogen either directly insert it into their distribution system, a small amount they're able to be directly inserted into the distribution system, and we're looking at that and seeing how resilient our system would be to that. And we're also looking at re-methanizing it with Biogas CO_2 and/or other type of CO_2 sources, and making it into renewable methane back into the system. Next.

And people say, "Is this pie in the sky?" "No, it's not pie in the sky. Germany is doing it, and if Germany is doing it, we can do it, right? We're the United States." So we could do this. They've actually got a lot of I think about up to two dozen plants that they're putting in, and they've already put in two, so we know they're already doing it, it's happening, it's not pie in the sky, this is happening in Germany today.

We're also looking at using natural gas to strip off the hydrogen and using it in hydrogen fuel cells for cars.

And we're working with University of Irvine to basically look at a study of how we would integrate the commercial power to gas storage and into our system, so we're looking at that now.

Ultimately, you know, we need to think bigger, we can't pick winners, we need to think, you know, this is like an ecosystem and we can't choose one over the other, we have to be broad and what we know today may not be what we know tomorrow, and we're a very innovative country, we're very innovative people, we can solve this. And this is something that's very solvable and we need to look across the whole energy system to do this. Thank you.

CHAIRMAN WEISENMILLER: Thank you. So a couple questions. One of them is, I'm trying to understand how much money in total are you spending now on leakage issues?

MS. HAINES: I don't have that number off the top of my head. I know that the amount of gas that we lose every year is about a tenth of our throughput, and that's worth about, depending on the price of gas, $3-5 million a year.

CHAIRMAN WEISENMILLER: Yeah, we talked about this this morning, on the one hand you have the Leno bill on implementation at the PUC, on the other end you have general rate cases which yours is ongoing right now, I assume PG&E will go back on the revenue requirement, and I don't know if it's next year or the following year, and the rate cases are where the rubber really hits the road on this is the amount of money you get, and so I'm trying to make the connection between this sort of doing the studies, but at the same time I think all of us will be happier just to start getting something in place. So certainly trying to get an understanding of how much money are we talking about, either now or in terms of what the requests are, and I think getting that for our record would certainly help put this in perspective.

MS. HAINES: And we could probably cycle back with CPUC and get those numbers back to you.

CHAIRMAN WEISENMILLER: That would be good. And I think the other question is that at one point SoCal Gas did a lot with seismic cutoff valves --

MS. HAINES: The Excess Flow?

CHAIRMAN WEISENMILLER: Yeah. I don't know where, but if I recall correctly, that just sort of died at some stage, but certainly in trying to understand again what seismically active area and basically going forward, one of the things where we could have sort of major leakage is if you have a seismic event.

MS. HAINES: Yeah. I could circle back with our person in charge of that. I know there's been a lot installed of excess flow valves, and they would shut off after a certain -- and I understand there are sensors that you can measure the tilt, that we might be able to put on the meter and, again, use that sensor to throat through our advanced meter network in case it tilts too much and we know that it could cause too much strain on the components, on the meter set assembly, and so there's a lot of things we could do now to help make sure that something doesn't happen after an earthquake.

CHAIRMAN WEISENMILLER: Yeah, again, I was just thinking the Bay Area, earthquakes there and fires, you know, often it's not unusual to look around and just see the gas system still going on, you know, after the disaster.

MS. HAINES: Yeah.

CHAIRMAN WEISENMILLER: And that would be the other part to try to pin down. But I think, you know, also certainly on the power to gas side, because I've visited 50 percent of the German facilities, but there were certainly much more engineering demonstrations. I was afraid to ask what the cost was, just given they certainly were just trying to get them up, so that's one of the things we'll need to understand better ultimately is the cost.

MS. HAINES: Yes.

CHAIRMAN WEISENMILLER: I think you've hit my questions.

MR. STOMS: Okay, I'll hand it back to Heather, then, for the Public Comment period.

MS. RAITT: Okay, so we'll just go into public comment and if folks in the room, I don't have any blue cards, but there's somebody in the room who had a question, if you could come up to the center microphone? And just please identify yourself and --

MS. SMITH: Hi, thank you. I'm Allison Smith with SoCal Gas. And we appreciate the effort that you're making with looking at the fugitive emissions from the distribution system. I did want to make a couple of comments, one is we think that there's a great opportunity on the goods movement side, as you had mentioned earlier, and in Southern California that's a very big challenge. And there have been a couple of studies, the EDF Wheels-to-Wheels, and the U.C. Davis Wheels to Wheels study, that suggested very little benefit from natural gas vehicles on a GHG perspective. And as you mentioned, there are criteria pollutant benefits, but we also think that there are significant GHG benefits. When they looked at the studies, they've been using some of the older data, some of the great model data that actually has a very low CI for diesel; when ARB updated the LCFS data, they increased the carbon intensity of diesel by 10 percent. So we will think that there's at least a 15 percent advantage to natural gas, conventional natural gas over diesel. And so we think it's important in considering that when you look at the overall benefit that you update both the diesel side and the natural gas side.

I also wanted to mention, as you said earlier, the abandoned wells issue in Southern California and in other parts of the state, is also a significant issue and we've heard a lot of talk about looking at the distribution system, but we'd like to see more research on some of those other sources and how we can identify those and mitigate those, so we'd encourage looking more at those sources, as well, so that we can get a better handle on aligning the Top-down and Bottom-up approaches, and recognizing the other sources of emissions.

CHAIRMAN WEISENMILLER: Actually, I was wondering, you know, certainly on basically the goods movement question, you know, my impression from SoCal was there is at least some potential technology or manufacturers that could really help address this efficiency question. I don't know if you want to talk about that some, or provide some of that information for our record.

MS. SMITH: I can actually follow-up with Jeffrey from our company to find out about the fuel efficiency.

CHAIRMAN WEISENMILLER: right.

MS. SMITH: I think the improvements that they're looking at for diesel trucks, you'd see those also carry over to natural gas trucks, and so I do think that we'll see some narrowing of that difference between diesel and natural gas trucks, but in terms of more recent data, I'm going to have to talk to Jeffrey to see if I can get some more information for you.

CHAIRMAN WEISENMILLER: And do you have any sense of the question I'd asked about the comparison between FERC, or at least proposed FERC standards, and the PUC for the backbone/transmission systems?

MS. SMITH: I'm actually going to have to follow-up on that, I made a note to look into that because I'm not aware of a significant push on the FERC side for the GHG emissions, but I'll check into it.

CHAIRMAN WEISENMILLER: Okay, good.

Thank you.

MS. RAITT: Go ahead.

MR. KINNEY: Hi, good afternoon, Chairman. My name is Ryan Kinney. I work for Clean Energy. We're the nation's largest provider of natural gas transportation fuels. And just a couple quick comments. We do appreciate having this workshop, obviously it's very important to inform public policy moving forward, and we have a lot of the same questions for our industry as many of the other industries do here today.

As far as natural gas, renewable natural gas, we'd love to have a seat at the table moving forward, have a more prominent role and join other stakeholders in working on this moving forward. I would also like to see the CEC hold as much focus on the increase in renewables as it is on methane leakage, while we think that's a very important step to take in conjunction with this. And also, we're of course working very hard with the ARB staff on the LCFS and methane leakage is a very important topic right now in trying to inform the GREET model. So the Argon National Laboratory model titled "The GREET Model Expansion for Well to Wheels Analysis of Heavy

Duty Vehicles obviously would fill major gaps in that and we hope to see that incorporated. In fact, I think staff right now is looking to have a yellow sale even after authorization in July, so we're looking to have those conversations ongoing.

Also, the ARB is incorporating a short-lived climate pollutants concept paper at the moment I'm sure, as you know, and they're looking at research funding and we'd like to see them of course pick a focus on methane leakage, as well, within their menu of other things they're looking at. So again, I think our industry would be very keen to work with the CEC as a stakeholder in the process moving forward. Thank you.

CHAIRMAN WEISENMILLER: That's great. I'd also call for people where there's a sustainable freight transportation initiative coming up, we'd certainly encourage people to participate in that, and that's more ARB than here.

MR. MAGEE: Hi. I'm Chuck Magee with the California Public Utilities Commission. And I was intrigued with Diana's observation about the Smart Meters and being able to detect water leaks at the water meters -- or not water meters, I mean the water heaters. And so the Smart Meters, I think, have a benefit that we're going to continue to find as we develop algorithms to analyze usage and I was wondering if there was also an algorithm so that you could maybe come up with an algorithm to find water leaks at the active accounts, not just the accounts that have been closed. And also leaking gas appliances downstream of the meter, I understand that water heaters can leak gas and it goes out the vent, and the utility wouldn't necessarily find that in a leak survey, especially older houses that have leakier appliances. So I was wondering if there's more work we can do in that area with coming up with algorithms using Smart Gas Meters and probably Smart Electric Meters.

CHAIRMAN WEISENMILLER: I was going to encourage both of the utilities to comment on your question.

MS. HAINES: I think that's a great idea and we are looking at using methane sensors right now, and hooking that with our advanced meters and seeing how low we can go in terms of the consumption data, but we don't have the money right now to go further on that, and we really do, we need to get some research funding for that and that's where we'd love to work with California Energy Commission and anybody who wants to put in some money to help us expand that.

MR. RONGERE: Yes, Chuck. My comment would be the same. I would love to look at that more. I think there are a lot of opportunities there. We are just scratching the surface of what we can do with the Smart Meters. There are also some limitations, either the technologies to our smart meters, so we cannot do everything we would like, but we are working actively on trying to extract as much as we can in terms of information from our Smart Meter data. So it's a work that we are doing, we would like to do even more than that.

MR. MAGEE: Thanks.

CHAIRMAN WEISENMILLER: Well, I was going to say that Laurie ten Hope isn't here, but Mike Gravely is here and, again, as we go through on the PIER Gas R&D activity, one of the things we really look for is public input on that, and unfortunately often we get the researcher coming in saying I do great work, give me more money, and it's good to have that sort of more policy driven analysis saying we really need work on, say, algorithms, or we need work in this area, that we can then have the researchers compete on who can do the best job there. Mike? Please.

MR. GRAVELY: For the WebEx, this is Mike Gravely from the R&D Division. I'd just point out in the written questions, when we do safety research we typically are very cautious not to duplicate the work that you're doing, so if you can make recommendations of areas, particularly in the safety area, if you can make recommendations of areas you think the research would be valuable, and obviously if you make recommendations we're not duplicating your work, but one of the challenges we have in the safety area is we have to be cautious that we don't in effect vest in something you are already investing in. So we would welcome your advice and recommendations for us as we do future plans, it would help us understand better how we could do research in the safety area that would deflect with the work the utilities are doing or planning on doing.

CHAIRMAN WEISENMILLER: Yeah. I guess we should both flag that, for our next Investment Plan in this area, the PUC has a draft decision which would direct us to shift more into climate and the safety issues, and also put in some of the money which was unspent. So I think we're going to be – I forget the precise timeframe we were directed, but assuming the decision goes out, we're going to go back and make adjustments to increase research in those areas.

MR. GRAVELY: Yes, sir. The draft decision, if it were approved, it recommends we do an updated proposed budget in 90 days to include those three topics, climate change, safety, and the pipeline.

CHAIRMAN WEISENMILLER: Yeah, it might make sense, Mike, to post our old investment plans so that people can look at which -- we're going to be adjusting, but anyway it gives them at least a baseline to look at some of the areas we're going to try to enhance.

MR. GRAVELY: We will, but we don't typically post it to the PUC, so they'll approve the plan with decisions, so after July when they've approved a plan, we'll post it and then of course we'll work whatever they direct us to work, or any changes we'll make. But we post a plan after they approve it and we expect approval by the end of June.

CHAIRMAN WEISENMILLER: That's good.

MS. RAITT: Okay, anyone else in the room who would like to make a comment? No. And I don't think we have anyone on WebEx, but there is, if you're on the phone line and you wanted to make a comment, we'll go ahead and open the line. And if you didn't want to make a comment, please mute your line. Okay, I think we're done with public comments.

CHAIRMAN WEISENMILLER: Okay, I want to thank people for their participation today. You go through written comments, go through that part.

MS. RAITT: All right, yeah, just to say that written comments are due June 15th and written here is the information for how to do comments, and it's also in the notice which is available on hard copy at the entrance and online.

CHAIRMAN WEISENMILLER: So again, we encourage people to submit written comments, certainly, I'm particularly interested in sort of what are the major areas of uncertainty or potential focus we should have on the R&D side. And just basically what next steps, particularly in terms of research priorities. So again, thanks for your participation and this meeting is adjourned.

(Whereupon, at 3:02 p.m., the workshop was adjourned.)

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