

Fracked Nation

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Greg Dalton: Welcome to Climate One, a conversation about America's energy, economy, and environment. To understand any of them, you have to understand them all. I'm Greg Dalton.

Today we're poking into the world of hydraulic fracturing or fracking. New technology for releasing gas bubbles trapped in shale rock has released a bonanza in several states. Landowners who sell their mineral rights are becoming instant millionaires while truckers, drillers and others also making a pretty penny. Champions of natural gas say we're entering a golden age that restores American manufacturing competitiveness, creates jobs and reduces greenhouse gas emissions. On the other side, people living near some wells are getting sick and lighting their faucets on fire. Natural gas detractors say water supplies are being risked and that fuel really isn't any cheaper, any cleaner than the coal that's replacing to generate electricity.

Over the next hour, we'll look at the good, the bad and ugly of fracking with our live audience here at the Commonwealth Club in San Francisco. We're pleased to have with us three experts. TJ Glauthier is a former Deputy US Secretary of Energy and a former board member at Union Drilling. Kassie Siegel is director of the Climate Law Institute at the Center for Biological Diversity. And Mark Zoback is a professor at Stanford University School of Earth Sciences and was a former member of the fracking panel convened by former US Secretary of Energy Steven Chu. Please welcome them to Climate One.

[Applause]

Greg Dalton: Welcome, everyone, thanks for coming. Mark Zoback, let's begin with you. Fracking is a new technology, certainly a new term to many people, but it's been around for quite a while, so tell us how you first learned about or got knowledgeable about fracking.

Mark Zoback: Well, in my case, hydraulic fracturing was being used for a purpose other than extracting hydrocarbons. It's actually a way to measure the magnitude of the forces that are in the earth. So I started working in hydraulic fracturing in 1975 in the Mojave Desert and we're trying to understand the forces to better understand earthquakes on the San Andreas Fault. So my introduction to it was sort of a nonconventional introduction.

Greg Dalton: And then how about with regard to hydrocarbon extraction? When did that become something on your radar?

Mark Zoback: Well, it's always been there. Hydraulic fracturing has been around since the 1940s, the late 1940s. It has a long history. It's always been part of oil and gas development, principally applied to formations with low permeability. If the oil and gas wouldn't flow naturally, a hydraulic fracturing would speed it up. The modern version of hydraulic fracturing, horizontal drilling and multiple hydraulic fractures from what's called the toe of the well back toward the heel really started about seven or eight years ago in the Barnett Shale in Texas, an area close to Dallas-Fort Worth. And that was really the beginning of what's now being called the Shale Gas Revolution.

Greg Dalton: Okay, about seven years ago. Kassie Siegel, when did you get involved in this business of fracking?

Kassie Siegel: Oh, it's been in the last four or five years that the issue has really started growing, first nationally, calling for a moratorium on fracking, as the people that were experiencing the first booms in Pennsylvania were telling their stories about what was going on. And recently, it's just being really ramping up here in California, as we've realized that California has the largest shale oil reserves in the country, and that if nothing is done and the boom takes off here that large areas of California could be transformed almost overnight, as we've seen in Pennsylvania, North Dakota, Texas and other places.

Greg Dalton: And we'll get into the pros and cons of that transformation. TJ Glauthier, set the stage for us in terms of how much fracking is going on. This is something that's new to a lot of people in terms of its impact and scale. How much fracking for natural gas really is going on right now?

TJ Glauthier: I'm not sure the exact number of wells, but it's something like 60 percent or more of the oil and gas now in the country is being produced with the aid of fracking. So it's a large amount. It's tens of thousands of wells that had been fracked and is a practice that is regulated at the state level. We'll talk more about that, I'm sure, but --

Greg Dalton: Right.

TJ Glauthier: -- that varies from state to state. There's a lot of it and it's a common practice now. I think it is probably eight years ago or so that it became more frequently used. So it's really been the last five years that we've had this huge explosion of gas availability and gas prices that have gone down to such low levels.

Greg Dalton: So something it's only seven or eight years old and now it's involved in 60 percent of the wells. That's something that happened pretty quickly. Mark Zoback, can you help us with the scale and sense of how much of this is going on, and its impact on the energy supply?

Mark Zoback: Well, right now, there are about 20,000 wells a year that are drilled horizontally and then hydraulically fractured. Each well has between about 5 and 15 hydraulic fractures on average. So there's 20,000 wells, roughly 200,000 hydraulic fractures carried out every year. There are 150,000 or so shale gas wells that are out there currently producing.

Greg Dalton: And what's been the market impact of this new technology?

Mark Zoback: Well, it's been remarkable, the local benefit to state economies, whether it's jobs or tax revenues. At the national scale, people are talking about a manufacturing renaissance in the Midwest. I guess we'll see if that comes about.

American consumers are paying one-third for natural gas what they were paying before the large scale production of shale gas. And on the other side of the coin CO2 emissions from coal are down 20 percent in just the last few years. And all of the other pollution problems, health problems associated with coal are also diminishing, thanks to the increased use of natural gas. So there are many positive benefits, but there are also environmental impacts and that's why we're here to discuss tonight.

Greg Dalton: Kassie Siegel, do you agree that natural gas is better than coal in terms of health impacts and climate impacts?

Kassie Siegel: I don't. The fracking boom has transformed our energy economy, but I think it's come at an unacceptable price. And the fact is that fracking poisons our air and our water. It brings terribly intense industrial development to previously peaceful communities. The nature of shale

development is that you have to drill lots and lots of wells, and to keep up production, you have to keep drilling more wells. It's conventional development on steroids. And sometimes fracking is promoted based on the argument that natural gas is a climate-friendly fuel, but it's not, and it's actually been called into question whether even burning natural gas in a power plant is better than burning coal. If the methane leakage rate during production and transmission is higher than about 3 percent, then the actual life cycle of carbon impact to burning natural gas is actually worse than coal. So it's not a bridge to a clean energy future. It's actually a bridge to extreme climate disruption because the fact is that we have to leave the great majority of fossil fuel reserves in the ground today.

That's global warming's new math and we're running out of time to solve the problem. Coming off the warmest year on record, Frankenstorm Sandy, epitomizes the increasing damages we're facing from the climate crisis. And, you know, fracking promises us 100 years of natural gas, but we can't burn that natural gas. We have to transition as rapidly as possible to a clean energy future, and I think we should do that without fracking and without trashing our air and water and our health to get at extreme and unconventional fossil fuels, but instead make the renewable energy transition.

Greg Dalton: So, TJ Glauthier --

TJ Glauthier: Can I disagree with that?

Greg Dalton: I was thinking you would, yes.

TJ Glauthier: Okay. I think that natural gas has a very important role to play in our conversion to a cleaner economy and a cleaner future. I don't think that it is at all worse than coal. I think coal is something that we've depended upon for 150 years. It's had a role that's been important, and it is extremely dirty and dangerous, you know, all sorts of problems that we are moving away from. And we're doing it naturally, the economics of gas or actually doing that. And so we are using less coal, more gas and what we ought to do is focus on how we make this transition in an effective way, so that we can get more and more renewable energy, more conservation, get more out of the energy than we are using. And I think the issue with gas and fracking is that we need to regulate it well.

So we need to produce gas this way and oil. Fracking has been used for oil production now, too; it's not just gas. But we need to regulate each stage of what we're doing, the actual drilling operations, the fluids that we use for fracking, the production process. And go right through each of these areas. I think it's possible to do it in a way that's responsible and safe and will help us move ahead to an appropriate future.

Greg Dalton: Let's go to this gas versus coal question a minute. In January of 2013, the journal Nature had an article that said there was an eye-popping "9 percent release of methane from some shale oil area in Utah." That's double what the industry figure had been. And at those levels, natural gas is not cleaner than coal because methane is so much more potent than carbon dioxide.

Would you agree that that's a key figure? That the life cycle, that comparing coal and gas depends on the amount of methane released in getting the gas out?

TJ Glauthier: Yes. Methane is a more powerful greenhouse gas substance. So if the leakage rate is high enough, then that will be a problem. But I think that one incident, I'm not familiar with the details of that one, but I don't think that's something you can characterize as being typical or representative.

Greg Dalton: But many people would say we're not sure how much that's -- that we don't know how much fracking is -- methane is being released from fracking. So, Mark Zoback, do we really know? You mentioned a number of -- thousands of wells. Are those wells being monitored of how much

methane is being escaped during the use of those wells?

Mark Zoback: Well, they're not being monitored adequately. And this is a really important question and a lot more work has to be done. You know it's interesting, the study in Utah has nothing to do with shale gas wells. And the fact of the matter is poorly constructed wells are a real problem in the oil and gas industry and always have been. And it's a legacy of leaking wells that has to be addressed, but it's a different topic. What it has in common with shale gas development is that it's not the hydraulic fracturing that causes the problem.

In every single case that's been investigated, it's a poorly constructed well that's caused a problem. And we know how to do that better. So really it's completely unrelated to hydraulic fracturing. It is related to shale gas development and one would say if the leakage is occurring, the leakage is occurring, and therefore, it's bad. It is bad and needs to be stopped, but the way to stop it is to do a better job of having better standards, better enforcement, better regulations and better enforcement of the regulations of how the wells are constructed, and to follow that up with monitoring, so identify what the problem is and then go out and solve it. The problem is not actually the hydraulic fracturing.

Greg Dalton: Kassie Siegel, do you agree this is a problem that can be solved? That the methane can be contained, and if that happens, then gas will be better than coal?

Kassie Siegel: Methane from oil and gas can absolutely be reduced, and we need to do it. We're not going to turn off the switch on fossil fuels tomorrow. There will be some fossil fuel use in the next few decades as we transition. And everybody has known that controlling methane from oil and gas is a critical thing to do. That's not new. The EPA put out a big report on short-lived climate forcers in 2006, talking about the readily available, cost-effective and even cost-positive measures to capture methane from oil and gas wells absolutely. But the thing is it's often natural gas -- if you captured all the methane, it's often compared as if we did capture all the methane to other impacts. But the fact is is that we're not. We're not doing it. We're not reducing other air pollutants. And the EPA has just missed an opportunity in a Clean Air Act rule-making to control methane from oil and gas. And so I just think that the solutions have been around for years and we haven't adopted them, so I don't think we can use the fact that you could clean up oil and gas as an excuse from getting away from the big policy changes that we really need to drive us off of all fossil fuels.

Greg Dalton: So do you think there ought to be a moratorium, a ban right now, a sort of pause or that how should the US proceed and states proceed with this that's happening it sounds very quickly the last five years, thousands of wells?

Kassie Siegel: I absolutely think we should have a ban on fracking. I mean, I and many others are also working for an end to burning coal to protect the arctic from drilling and for no Canadian tar sands and no Keystone pipeline. But I think no fracking is a big part of a really sensible energy policy going forward.

Greg Dalton: But is that -- even some environmentalists would say that's not pragmatic, that fracking is here, it's a reality, it's mainstream technology, it's not going to happen. Environmental Defense Fund, other world environment organizations will not support a ban.

Kassie Siegel: Well, I can imagine a world with no fracking and I can imagine a world where the United States doesn't spend \$500 billion a year on fossil fuel subsidies. And I think we can do it with renewables. Mark Jacobson down at Stanford has a great new study out on how New York can get to 100 percent renewables by 2030. And New York is a tough case because New York right now is almost completely dependent on coal, oil and gas for its energy, and he's shown how, with a fairly

substantial capital investment, you could get to 100 percent renewables by 2030. And that would be paid back in 17 years by the money you save from the health improvements alone in getting off of fossil fuels and he's working on a plan for California where, of course, we already have a large portion of our energy from renewables.

Greg Dalton: Update us on what Governor Cuomo has done in New York. He's gotten a lot of celebrity and press attention fracking in New York City probably because of the water supply downstate for New York City. So where is the fracking in New York state right now?

Kassie Siegel: Well, New York has a moratorium on fracking while they study the health and environmental impacts. And I think Governor Cuomo is having serious second thoughts about lifting that moratorium, because in New York there is a major, major public outcry about the impacts of fracking.

Greg Dalton: TJ Glauthier, is it wise in some cases to take a time out and study things like New York did?

TJ Glauthier: Well, I think what we need to do is to actually make sure we're regulating this properly. So Mark, for example, mentioned the way that the wells are drilled. The casing requirements for wells are in place and they need to be enforced, so we need to be sure that the depths of these wells go far below drinking water supplies. These wells are typically 8,000 feet maybe and the water supplies are in the first couple thousand feet. So we drill these and we make sure that the casings are submitted properly, they're inspected properly, all that is done; that will solve one part of the problem. I do think that we need also more transparency on the fluids that are involved in the fracking. There are chemicals involved in this, and we need to have a public awareness and access to that information. And there are trade secrets that some of the companies have, but we can manage that. There are ways to have that information given to government agencies, who are the regulatory agencies, and we can try to make sure that side of it is being done properly.

We can also deal with the wastewater side. We haven't talked about that, but one of the biggest problems is the waters that come back up after fracking are contaminated with a lot of materials that are underground in this deep aquifers or deep formations, and those wastewaters are actually some of the things that have caused the biggest problems, both in terms of disposal and in the seismic or the earthquake risks that have been a concern in certain areas. It's not the fracking that causes that problem; it's the wastewater disposal.

And we need regulations that will properly control the quality of that wastewater or what we do with it and encourage people to reuse it. So instead of using several million gallons of water to frac a well and then use a lot more water or the same amount the next well, you can reuse a lot of that water and half of that water can be reused time after time. So I think there's things like that that we can do that will make this practice much more responsible and a sound one while we continue to work on the things that Kassie is talking about for renewables and the kind of infrastructure investment that will take us in the long term over to a whole different energy supply.

Greg Dalton: And that needs to happen quickly because there could be contamination happening out there right now that this is a case where technology and businesses is way out ahead of policy and rules, right? So how's government going to catch up?

TJ Glauthier: Well, some of those rules are actually on the books now. We need to be sure we're enforcing them. For example, the casing requirements for wells, that's not new. It's a matter of making sure that we have the right people out there inspecting these wells as they're being cased or

the like and done.

Greg Dalton: Mark Zoback, Pro Public reported a couple of years ago that there've been a thousand incidents documented in Colorado, New Mexico, Alabama, Ohio and Pennsylvania of groundwater contamination. So there's already a lot of damage out there. I want your comment on that and then also what to do about water management.

Mark Zoback: Well, that -- and that comes back to the leaking well -- the poorly constructed leaking well problem. It's not the hydraulic fracturing problem and it has to be addressed. Let me just back up and cover something. When our Secretary of Energy Committee looked at the shale gas development issue, we were unanimous in affirming that shale gas can be developed in an environmentally responsible manner, but we also pointed to 20 different areas where things had to be done better.

And we've identified the problems and recommended solutions. And so switching to natural gas is not a "get out of jail" card. We have to proceed responsibly or we obviate the benefits. We totally agree. And if gas is going to be a transition fuel or a bridge -- a blue bridge to a green future, there's got to be something on the other side of that bridge and that's got to be renewables. And so I think we -- there's a lot we agree about. The real question is how we transition from where we are to where we're going and whether or not natural gas is going to play a role in that transition and there's no reason why it cannot.

Now the issue with water is just part of one of these 20 issues, and in some parts of the country, there's a lot of concern about the water that's being used for hydraulic fracturing. But it really is only like 1 or 2 percent increase in water use in that area. The flowback water, where it's convenient to inject it, like in Texas, it has been injected. Where it's inconvenient to inject it, like Pennsylvania, it's being totally reused and recycled, and you get away from the injection problem altogether, and you put the arsenic, selenium and the other contaminants that come back in the flowback water, you put them back where they came from because they're coming from the shale originally and you put them back there. So there's -- it's a large scale industrial process. There are lots of problems, but if you identify the problems, you can also identify solutions to those problems and you can move forward in a responsible way.

Greg Dalton: And what are the consequences for their problems? If someone is fracking, a company is fracking and groundwater gets contaminated, as there's alleged thousand incidents, what's the recourse for communities? What's the penalty, TJ Glauthier, for a fracker contaminating groundwater? What's the recourse?

TJ Glauthier: Well, there should be total accountability responsibility. I'm not sure the difference in state to state.

Greg Dalton: Because there's a federal in 2004, the Safe Drinking Water Act, there's the famous Halliburton Loophole that exempts fracking from that process. Should that be closed?

TJ Glauthier: Yes. I think that the Safe Drinking Water Act ought to cover this kind of wells. And I don't know if everybody is aware of it, but this was an amendment passed in 2005 that exempted oil and gas wells, and it was labeled the Halliburton Loophole because the vice president at the time had something to do with Halliburton and there was a sense that there was --

Greg Dalton: Well, but our --

TJ Glauthier: It came from the energy policy committee that he had.

Greg Dalton: But also the EPA at that point had said, Kassie, that fracking was not a problem, right?

Kassie Siegel: Well, they did a report in 2004 and they looked only at fracking for coalbed methane and that report has been totally discredited. And they said, "Oh, it's fine, you know, no problem," or at least it was spun that way, and after that report came out, then we got the Halliburton Loophole. But the EPA now admits that we don't even know all the risks from fracking to water and they're studying that in a very major process. It's been going on since 2010 and we won't have any results from that until 2014. But while they're doing that, fracking is going on around the country uncontrolled or very, very lightly regulated and the consequences are really, really serious. They were serious for a rancher named Ned Prather in Colorado who turned on his tap one day and drank a glass of water that had benzene in it at 20 times the limit that EPA considers acceptable. His throat started burning. He got dizzy. He was immediately taken to the hospital. He didn't die, but it was serious and that's a very, very rare instance where that driller was actually fined.

But another story that for me really exemplifies a lot of the issues that we're wrestling with here now is the story of Larry and Laura Amos, and they're also from Colorado and they experienced one of the earliest fracking booms out there. And one day, their drinking water well just exploded, like a geyser. And state regulators came in and they said, "Well, that was methane contamination, but don't worry, everything is okay. The methane won't harm you." And Laura and her husband and their infant daughter continued to drink the water. Laura continued breastfeeding her daughter for 18 months, and a few years later, Laura was diagnosed with an adrenal tumor. And it is a really rare condition that's caused by a chemical used in fracking called 2-butoxyethanol. And for a long time, the drilling company denied they even used that chemical, but then it finally came to light that they had. And after that happened, the Amoses got a settlement and the state regulators also fined that driller. But in that report, for reasons that have never been explained, Colorado regulators concluded that fracking didn't cause the problem, even as they were fining the company.

And so officially, there's no problem from fracking there. But I think most people that hear the story say, "Hey, there's a really, really serious problem here with fracking and the chemicals." But the oil and gas companies and, I mean, I'm delighted to hear that we all -- everybody here tonight agrees that there's a big problem with fracking in water because the oil and gas companies keep denying it. And they do that based on splitting semantic hairs and by benefiting from the fact that we almost never have a monitoring system in place that's adequate to detect the problem unless there's some major accident or disaster that happens.

Greg Dalton: For those joining us, Kassie Siegel is director of the Climate Law Institute of the Center for Biological Diversity. Our guests today at Climate One are TJ Glauthier, former deputy US secretary of energy, and Mark Zoback, professor at Stanford University School of Earth Sciences. I'm Greg Dalton. Our Twitter handle is @climateone, if you're tweeting on this. And also podcasts of this and other Climate One programs are in the iTunes store.

Mark Zoback, where is this regulated well? Kassie talked about Colorado. Colorado has since passed some -- as what some people might call some of the more aggressive oversight regulations of fracking. Is it Colorado, or where else do you think the regulation is going well?

Mark Zoback: Well, Pennsylvania sort of stepped up when activity began there and the then secretary of Environmental Protection, John Hanger, hired I think it was 90 new regulators and trained them and put them in the field and put them right to work. So there are states that are responding to the need for better regulation. I want to address one point that Kassie raised and these instances are really heartbreaking and regrettable, and finding out what happened in each and every case is important. But when you look at the data, we have a lot of experience. If you look at

the Barnett Shale in the Dallas Fort Worth area, there's 16,000 wells. The study of those 16,000 wells by the NREL, the National Renewable Energy Lab in Boulder, Colorado, a DOE lab, says that the methane emissions are no worse than we pour -- than the -- well, let's just put it this way, the total greenhouse gas footprint is half the amount of burning coal. So are there methane emissions? Yes, and real points to fugitive emissions and points to methods to reduce them even more. But the net effect is that using gas from the Barnett Shale produces half as much impact on the climate as burning -- on burning coal, 16,000 wells and there have been reports of cancer hotspots, all of which have not proven to be valid once they're looked at carefully. And there are no reported cases of widespread aquifer contamination.

Now, I'm not an apologist for industry. I'm spending a lot of my time trying to enact things like those 20 ways to do things better. But we have to look at what the data say and not the regrettable accidents or instances, and damn the entire process and the entire opportunity that is presented to start decarbonizing our energy system and moving away from coal. So enough on that.

Greg Dalton: On water contamination, you say there's no reported incidence. Is there enough testing going on before and after to know -- the question is, "Well, it's not happening. Well, are we looking -- because of the water underground, how do we know what's in the water?"

Mark Zoback: And that's a fair point. Most of the companies won't drill now unless they can sample the water ahead of time just to protect themselves from future litigation, but there's not enough monitoring after they drill. I fully agree. A lot more needs to be done, and if problems arise, we have to get to the bottom of it. And if we have to cease operations in an area until we get to the bottom of it and figure out what the solutions are, so be it. But it's not -- there's nothing out there that argues for a widespread moratorium. Now, the issue about regulations is really complicated because every state has jurisdiction. And there are 23 states, I believe, where shale gas is now being produced. And some states are trying to do a good job, one could argue whether they are or not, and some states are sadly not even trying. And so the real issue is how to improve operations and especially improve the operations associated with the smaller companies. As more and more big companies get into this business, they're doing a better job. They have more, more expertise, they have more at stake, they're going to be in the business for a long time, and they have more to lose, if people go after them in lawsuits.

So if you actually look at the numbers, the big companies are doing a good job. The intermediate size companies are doing an okay job, they can do better, and the small companies are where the problems are. So we need a regulatory system that brings up the bottom, that looks at what the worst actors are doing, and corrects the problems they're creating by not being as responsible as they should be. And that's a state by state battle and it's now going on. And frankly, there are states that need to do a lot better. They need to try harder. They need to adopt the practices for regulatory reform that are working well in other states.

Greg Dalton: Is West Virginia one of those states?

Mark Zoback: Part of the testimony that was given to our Department of Energy committee, that statement was made. And so we've heard that from others, that West Virginia was not doing nearly as good a job as Pennsylvania. It's not something we studied independently.

Greg Dalton: Kassie Siegel, do you agree that the little guys, little operators are the problem? There's thousands of them. How are we going to get at them?

Kassie Siegel: Well, I think that they certainly are a problem, but, I mean, maybe the more immediate problem in terms of the regulatory discussion is that a number of bodies, including the

shale gas subcommittee that Mark was a part of and others have made a lot of recommendations.

And not surprisingly, when they looked at the question, "Could we do shale development better and cleaner?" they found that, "Yes, we could." And they made recommendations like capture the methane, capture the traditional air pollutants, readily available measures today to do that, ban fracking with diesel, full disclosure of fracking chemicals, good common sense stuff, right? But for the most part, with a couple of very limited exceptions, they're not being adopted. The states haven't adopted them and even the Bureau of Land Management, which is a federal agency in the Interior Department, manages oil and gas leasing on 40 million acres of public lands. They're doing a rulemaking on fracking right now, and they adopted almost none of the recommendations of the shale gas subcommittee.

They just put out a revised draft of their proposal. They proposed it once last summer, and then they've just put out a new version, because they weakened what they proposed on how to deal with trade secrets. And they've put out a proposal that I think most people will find quite shocking about the chemicals. They said, "If oil and gas company claims that the chemicals used in fracking are trade secret, they don't even have to give us the information." So the Bureau of Land Management won't even take it. And they say, "Oh, don't worry, we'll make the drillers keep the information for six years." But you might have a problem more than six years out or you might have a company, probably one of the little guys, go bankrupt. They're gone. You can't find the information and then you have somebody in the hospital and the doctor really has no way to get the information they need to treat them. So, I mean, you can understand why anti-fracking activists are a little bit skeptical of this ever receding claim of "Don't worry, we're going to clean it up" because we know how to clean it up and we've known that for years. But it still hasn't happened.

Greg Dalton: Kassie Siegel is director of the Climate Law Institute at the Center for Biological Diversity. Mark Zoback, is it true that a lot of the recommendations of the panel you're on have not been adopted?

Mark Zoback: Well, I think Kassie said it well and I think every member of our committee is frustrated by the fact that our recommendations were not followed to the degree that we like to see them followed. And if you could help get them enacted, I'd greatly appreciate it.

Greg Dalton: TJ Glauthier, the Bureau of Land Management, you were formerly in Department of Energy, not Department of Interior where BLM is, but it sounds like they're playing catch-up there?

TJ Glauthier: Well, they are and they've been very aggressive in trying to promote more energy development in ways that are clean. So they've done a lot with solar on federal lands and done more with wind farms on federal lands. And I think this was viewed by Secretary Salazar as one part of a strategy to try to be more progressive. But the regulatory side of this does have to be dealt with and I think that's one of the reasons that federal regulations, Safe Drinking Water Act, things of that sort, are one of the solutions that it can't really all be done at the state level.

Greg Dalton: So where's the pass for that? Is that an act of Congress to include fracking in the Safe Drinking Water Act?

TJ Glauthier: Unfortunately, it is. It's Congress that passed that Halliburton Loophole and it's Congress that has to adopt that. And our Congress right at the moment is not doing too well.

Greg Dalton: How would you all rate the Obama administration and their approach toward natural gas development, natural fracking and oversight? Kassie Siegel?

Kassie Siegel: I'd give him an F.

[Laughter]

Greg Dalton: Mark Zoback?

Mark Zoback: I'd give him a C. And I think all of this discussion is really -- has to be a discussion in the context of an overall energy policy. Natural gas doesn't make any sense if we're not going to be decarbonizing the energy system further and we have to have incentives in place, programs in place so that we can transition in an economically viable and socially acceptable way from fossil fuels to renewables. And we all should see that roadmap and we should know where we are on that road, and it's the goal of the government and the current administration to establish that roadmap and get the public's buy-in and recognize what our long-term goals are.

Greg Dalton: Is there an example of a bridge fuel in the past because once technology's developed, infrastructure's developed and invested capital in that infrastructure and jobs are created, then there's a constituency to defend and protect those jobs and those companies. So have we ever gotten off a bridge like that? TJ Glauthier?

TJ Glauthier: Well, I'd like to take that to a slightly different place. That is the -- right now, there are --

Greg Dalton: So that means no?

TJ Glauthier: Well, we can go back a long time at different trends. But I think your point is right, that once infrastructure built up, then there are a lot of interests in maintaining that. And the point I'd like to make is there's a lot of discussion about how much volume of natural gas we're going to have or oil and gas, and how fracking has solved our problems. We have a 100-year supply of gas. We actually, at the moment, are the largest gas producer of any country in the world. We've passed Russia now. We're a net energy exporter now as of two years ago. We are exporting more oil than we are importing. Those are things that are fine, but we should not expect this is going to continue forever. We should not build a whole lot of natural gas-fired power plants that are going to require us to keep that volume going forever. We -- we're terrible at our forecasting. Six, seven years ago, we were building LNG plants to bring natural gas into the country because we didn't have enough gas. Now we're talking about turning those around and exporting gas. Well, the one thing we know is we're terrible at forecasting the gas supply, the gas situation, the prices. I think we ought to be cautious. We ought to use the gas that we have. We ought to regulate it properly. We ought to use it for this bridge process, build facilities that will actually be appropriate to maintain for 30 or 40 years for their life but don't build everything to be using gas. Let's work this out, as Mark says, in a comprehensive kind of energy policy that shows a transition so that we are reducing the amount of energy we need overall. There's a lot we can still do in efficiency and in the conservation, that we use more and more renewable. We rebuild our electricity infrastructure to integrate those renewables and make it possible to do these things at higher levels.

Greg Dalton: TJ Glauthier, is former deputy US secretary of energy talking today at Climate One about fracturing natural gas. Mark Zoback, people who've been in natural gas business a long time know how volatile the price has been and how wrong people have -- fortunes have been made and lost betting on the price of gas, and whatever it is today, it's very low. It won't stay that way for every long, so I'd like to hear your response to that in TJ's point about the future of the industry.

Mark Zoback: Yeah. The gas industry is in an unusual place right now in the United States because gas prices are so low that nobody can actually afford to produce it because there's an oversupply. So the price has to reach some sort of equilibrium level where a company is going to afford to go drill, frac and produce the natural gas, and yet it is still cheap, affordable and done in an

environmentally responsible way. So we benefit from the health climate and pollution benefits of natural gas, and we're not there yet. The difference between where we are today and where we were 10 years ago when we saw gas prices spiking is we now know we have this enormous resource that we can produce at affordable and competitive prices. At a price where natural gas beats coal, almost every shale basin that's out there can be produced in an economically viable way. So the situation has really, really changed. I know the emphasis of this program is on the United States, but I think we also should look at the global picture. You know, we generate 2 billion tons of CO₂, or we were until recently by burning coal for electricity. China is burning 7 and that 7 is expected to go to 14 in about 20 years. If the US goes to zero through renewables or whatever and China meets its increased energy needs with coal instead of natural gas, they're going to go from 7 to 14. Our reduction from two to zero is going to be meaningless on a global scale.

Greg Dalton: So China should frac.

Mark Zoback: China should develop its shale gas resources in an environmentally responsible manner because, if they don't, they make the problem worse instead of better. But right now, they're on a path to make the greenhouse gas problem a whole lot worse than it already is. And this offers a bridge in China, it offers a bridge in South Africa, it offers a bridge in Argentina, it offers a bridge in Australia. The import of conventional gas offers an alternative to India-- with coal, they're very coal-dependent country for energy right now. And so this -- what we do in the United States is important because it sets -- it not only defines the technology but defines the standards that will be employed on a global basis. And so it's our job to do it right and we're not doing it right. There are at least 20 ways to do it better and there are probably more. But the stakes are extremely high and the stakes go far beyond the US border.

Greg Dalton: Point taken. Could more renewables be part of that transition rather than more fossil fuels?

Mark Zoback: Yeah.

Greg Dalton: Like Kassie mentioned, Mark Jacobson at Stanford earlier, that this is just perpetuating independence on fossil fuels?

Mark Zoback: Well, absolutely renewables are the solution. It's the rate at which they can be employed. Right now, they're 1 percent of the energy in the United States. We got a long way to go, but that's where we need to get and that's why we need a comprehensive long-term policy to get us from where we are to where we want to be. And it's wind, and it's solar and it's energy efficiency, and it's all of these things together.

Greg Dalton: Mark Zoback is professor of Earth Sciences at Stanford University. Our guests today at Climate One are Kassie Siegel, director of the Climate Law Institute at the Center for Biological Diversity, and TJ Glauthier, former Deputy US Secretary of Energy. I'm Greg Dalton.

We're going to put a microphone right here where Ed is sitting, and invite your participation to come and join the conversation with one one-part question or comment. I'm here to help you keep it brief, if you need some help. And the line starts with our producer, Jane Ann, over there. If you're on this side of the house, we please invite you to go back through that door rather than crossing these camera lines, and then we'll get you as part of the conversation here at Climate One. And I'll just ask one more question while we get that going.

Let's talk a little bit briefly about earthquakes. We touched on it briefly, but earthquakes are a big deal as part of fracking and can that be managed, Kassie Siegel, the earthquake around the wells?

Is that something that could be manage and reduced?

Kassie Siegel: Well, I'm sitting here with one of the world's leading earthquake experts, but in my opinion, it's a very, very serious problem, particularly from the disposal of fracking wastewater back into injection wells. And there has been somewhat of a controversy about an earthquake that took place outside Prague, Oklahoma. And there was a lot of damage done there. Some homeowners had a lot of damage done to their homes and no way to pay for it. Joe and Mary Reneau were some of the fortunate ones. Their chimney fell in to their living room, right on top of one of Mary's favorite places to sit, and she wasn't sitting there at the time. And they had earthquake insurance, so they were lucky. And Joe Reneau joked that he won the earthquake lottery, but he also said, "I think it was the injection of the wastewater, but the oil and gas companies are never going to admit it. Even if God himself came down and said the drilling company caused this earthquake, they're never, ever, ever going to admit it."

And that's a big problem. I mean, I think there's been all these studies back and forth. I think the evidence shows that injection almost certainly did cause that earthquake. I'd be interested in what Mark has to say on it, but it's a really serious concern and here we have this expanding fracking and wastewater injection going on in California, without the studies being done. We need to do this to assess the risk.

Greg Dalton: Mark Zoback.

Mark Zoback: Well, not to be too coy about it, the case of the Prague earthquakes really is kind of equivocal. I think there's evidence that point to injection causing those earthquakes and there are issues about it that suggest they might be natural earthquakes --

Greg Dalton: You wrote about Youngstown, Ohio, where there was -- okay.

Mark Zoback: Yeah, yeah. Well, I'm just going to say it. There are cases where the injection clearly caused the earthquake. So let's talk about those where the evidence is irrefutable.

Youngstown, Ohio; Guy, Arkansas; and the Dallas/Fort Worth Airport, in those three cases, the injection of wastewater caused the earthquakes. Now, this is something we've known about since the 1960s when the Army was injecting wastewater at the Rocky Mountain Arsenal outside of Denver. What happens basically is when the water pressure increases at depth, it makes it easier for a fault to slide that was going to slide someday as a natural geologic process; it just sort of accelerates that process. And so we have to avoid this. If shale gas is going to be developed in an environmentally responsible way, the flowback water has to be injected in an environmentally responsible way. And the best way to do that is not to inject it at all, to reuse it. But that's not required in many places. And so unless we do a better job of picking where and how much, how rapidly we inject the flowback water, more of these earthquakes are going to happen. And so that's something -- that's another one of these problems that we have to get out in front of and manage properly. We can manage it, we understand the physics, but we don't often do the site characterization to know if there's a potential problem. And so industry has to be more proactive to avoid the problem instead of kind of coming in afterward and denying everything. That doesn't get us anywhere.

Greg Dalton: Let's have our audience questions. Welcome to Climate One.

Audience: I am James George with Envirobeat. There's a popular expression that politicians use as "all of the above energy policy, I support all of the above," and I'm wondering, can natural gas fit into that and is it a realistic idea? For example, natural gas power plants can be ramped up and down very quickly to accommodate the gaps in wind and solar. But on the other hand, the low price

is making it hard for those other renewables to get on the market. So I'd like comments on that.

Greg Dalton: Double edge. Who'd like to take that? Mark Zoback?

Mark Zoback: Well, I think that's exactly the situation. I think a lot of the environmental push back to natural gas is that even if we solve the development problems, let's assume we did, it's still a fossil fuel. We're just producing half as much greenhouse gas as we did before. We're -- we would like to reduce that to zero and renewables are the way to do that. And in the absence of a policy, the cheapest form of energy will prevail, but that's not necessarily the best form of energy. And so we have to use natural gas as a backup for enhanced deployment of renewables. Sometimes the sun doesn't shine and sometimes the wind doesn't blow, and we require a steady base load and natural gas is the perfect backup for that. And as renewables and wind become a more and more significant part of the energy mix, it's going to need that relatively clean and rapid backup of combined cycle and natural gas plants to function effectively. What we can't let happen is cheap natural gas deflect the deployment of renewable sources, and that's a legitimate fear, and it will take leadership and good policy to prevent that from happening.

Greg Dalton: Good policy, meaning some subsidies. TJ Glauthier?

TJ Glauthier: I think that all of the above strategy that President Obama talks about is all of the newer advanced approaches to energy. It's not just to use everything that we have but to continue to try to advance our technologies and our practices in every area. So gas is a part of that, but it's all focused on this longer term transition to get somewhere else.

Greg Dalton: Let's have our next audience question. Welcome.

Carol DiBenedetto: Hi, thanks. Carol DiBenedetto. So I get very nervous hearing about regulation and thinking about how that's going to be done right when we have budget crisis, when we look to the financial crisis. And in my opinion, I don't think we're regulating correctly. The SEC budgets get cut continually and then we have a budget sequester where you have no idea what's going to be cut but probably regulation, in my opinion. So I would love to hear your opinion about why not ban fracking and put the cost of all of these analysis on the companies who make money. In the short term, it's a huge money-making proposition. So let them figure it out, let them become transparent about the chemicals, about the pillage of the possible environmental issues, let them foot the bill for it. What do you think about that?

Greg Dalton: Kassie Siegel.

Kassie Siegel: Well, I absolutely agree with you that we should ban fracking and we should ban other forms of extreme and dangerous fossil fuel extraction so --

Greg Dalton: But there's been some examples and it's noted ones with offshore oil drilling where the drillers paid the revenue -- some piece of the revenue from those leases paid the oversight agency which, TJ Glauthier, then becomes dependent on the agency, its overseeing for its budget, that didn't -- that ended in some sex and drugs and rock and roll, where at the bureau of -- at the Department of Interior, that didn't work out so well.

TJ Glauthier: The Minerals Management Service was part of the problem, that's right.

Greg Dalton: Right.

TJ Glauthier: And that's where they get their revenue from offshore oils' leases yeah. But I think the idea of it is a sound one to have some kind of fee that comes from the energy that's produced

that ought to go back to agencies that are overseeing the practices.

Greg Dalton: Okay. Let's have our next question. Welcome to Climate One.

Babette Hogan: Thank you. My name is Babette Hogan. I've been doing a lot of research on fracking, primarily in West Virginia but also in Colorado. In anticipation of what's going to happen to California though, of course, it's not as economically feasible to do it here as yet. My concern is that as we're beginning to see communities fight for their own rights and try to abate the process of large industry coming into their communities, that governors are actually relaxing the regulations required. We've even seen Governor Hickenlooper of Colorado drinking frac fluid and testifying that "It's just all safe." How responsible should we be out for calling out the politicians that are making this all possible, this devastation? Thank you.

Greg Dalton: Kassie Siegel, you're suing a whole bunch of politicians, why don't you take that?

[Laughter]

Kassie Siegel: We're actually mostly suing the regulatory agencies.

Greg Dalton: Oh, okay. They work for the politician, okay.

Kassie Siegel: But, yeah, and -- I mean, what we want to see in California is we want to see the fracking boom nipped in the bud because regulation hasn't worked other places. The regulatory proposal in California is extremely weak, adopts almost none of the shale gas subcommittee's recommendations. And, yeah, we can learn from what's happened in other parts of the country and say, "Hey, you know, we don't need to suffer these harms. Regulation hasn't worked. Let's just prohibit it. Let's put our societal investment into clean energy. That's what we have to do because of the climate crisis. You get way more jobs for that investment anyway than investing in oil and gas, and we just need to make this transition quickly.

Greg Dalton: Anyone else on that? Although I think some of the Dakotas would say that there is boom towns. There's lots of money and revenue coming into Dakota because of -- the Dakotas because of the shale gas boom up there. People are getting paid lots of money. The governors see jobs. That's very enticing for a politician who's got to run for office and sees money flowing into their state.

Kassie Siegel: Well, California is not North Dakota. And it's true that North Dakota does have a low unemployment rate right now, but they're having their health care system destroyed, they're having their roads destroyed, people are getting sick. We are sowing the seeds of terrible environmental problems, and it's a boom and bust kind of cycle. And North Dakota has been through the boom and the bust before, and they're left holding the bag. I mean, I don't think that's what we want for California. You may get some jobs in the oil and gas sector, but what about the risk to agriculture and to tourism and other industries that employ way more people than the oil and gas industry does?

Greg Dalton: Let's have our next question. Welcome.

Adam: Oh. Hi. My name is Adam. I live in San Francisco. Much of the talk has been on natural gas, but here in California, the big debate is fracking the Monterey shale for oil. And I'm assuming we're not considering oil as a bridge fuel tonight, so I'm wondering about the wisdom and possible impacts of fracking California for oil and whether there's any efforts like there are in New York to put a moratorium or some legislation in play to first stop that and have the debate about it.

Greg Dalton: I'll briefly say that we're going to talk about fracking in California oil in the second hour, which is a different radio program, but we can briefly address it here in terms of we've been talking about fracking for natural gas. Fracking is also used for oil. Who would like to respond to that? Mark?

Mark Zoback: Well, basically it's shale gas technology, horizontal drilling and multi-stage hydraulic fracturing applied to oil reservoirs that just have very low permeability.

And there has been a big boom in West Texas in very old oil fields because it's working so well to rejuvenate production from long depleted oil and gas reservoirs. And the idea in California is very simple. The Monterey formation has a lot of oil in it but has very low permeability and the hope is that the application of the same technology will work to enhance oil production

Greg Dalton: Let's have our next audience question. Welcome to Climate One.

Brent Plater: Thanks very much. My name is Brent Plater. I just have a question. I was really interested to see the panelists acknowledge some of the constraints of regulation for fracking, whether it's regulation, the problems with some of the agency corruption, financing it, finding a way to fund it. And yet there were still, for some of the panelists anyways, this kind of almost reflexive objection to a ban as an alternative regulatory strategy. And so I was wondering if perhaps you could provide us with some examples of some bans that have been effective or implement best practices or if you -- or maybe at the very least just tell us what your bottom line would be to support a ban. What would it take for you to be in favor of a ban as opposed to a regulation-type strategy?

Greg Dalton: TJ Glauthier, how about -- you know, ban's a big word. How about a timeout to allow policy to catch up to the technology, a pause, because it's racing ahead right now?

TJ Glauthier: I think there is a lot of merit to that and that is probably the way to characterize what happened in Pennsylvania where Pennsylvania took time to look at this, develop some good regulations and I think I would agree with Mark's statement earlier that Pennsylvania used to be now approaching this well and appropriately. And that some of the problems early on was with the wastewater which was written about where, mid-Pennsylvania, they took it to other states where they dispose of it in ways that were not appropriate. That's one of the areas it's been clamped down on that people in Pennsylvania now are not able to do that.

So I think if it's that sort of thing -- right now, what's happening in California, as my understanding, is that the regulatory process is playing out and what we need to do is, I think, put the right kind of pressure on people here to get those regulations straightened. So they are at the right level, so they'll actually protect us.

Greg Dalton: Mark Zoback, can you envision a scenario where a pause or a timeout would be appropriate to let policy catch up with technology and say, "Look, this thing is going ahead so fast, we got to hit the brakes for a while," to get it right before some of the bad mistakes happen?

Mark Zoback: Well, I think that's actually already happening due to the low gas price. But I think the right thing to do is for public interest groups to make sure the government, through the regulatory process, is only allowing development to go forward at a pace commensurate with its ability to regulate what's happening. And that's what should be done. We shouldn't open the doors to development. It should be occurring at the appropriate pace, that it's being regulated properly. We're not relying on self-enforcement. We're not relying on old and inadequate regulations. We're doing sufficient regional planning. A lot of wells are being drilled. And we have to look at the regional impact on communities, ecosystems, infrastructure to do it right. And so I think in each and

every state, the challenge is for the development to occur at a constructive pace, at a pace where you're not doing more harm than good. And that, if you want to call that a pause, I would just simply say you slow down to adapt to local road conditions and don't go any faster or accidents will happen.

Greg Dalton: Well, but there's no real incentive for a company that's got investors, trying to make as much money as possible. They're incented to kind of drive as fast as they can to get that revenue flowing to monetize their investment, right?

Mark Zoback: But that's why we have regulators and that's why we have regulations, to not allow that to happen.

Greg Dalton: Kassie Siegel?

Kassie Siegel: I appreciate TJ's perspective so much, but I cannot agree that they're doing it right in Pennsylvania. Pennsylvania, they have a law allowing trade secrets to be withheld. They have to be provided to doctors, but they have a gag order on what those doctors can do with the information. There is an article in the New England Journal of Medicine just this week by physicians decrying the interference in the physician-patient relationship, saying they have to be able to share not only everything they know but everything they suspect with their patients when they're treating them. Pennsylvania has just limited the amount of a setback you can have between an impoundment of fracking waste and residences. So it actually passed a law saying you can't require it to be any further away in, like, 400 feet or so placed a limit on that. They still allow road spreading in Pennsylvania of oil and gas waste under some condition. So I just can't agree that Pennsylvania is getting it right, and the people in Pennsylvania are suffering terribly from oil and gas right now, from the shale gas.

Greg Dalton: Is it time for the federal government to come in? Is there a place for the Feds to come in and to do something on this? TJ Glauthier?

TJ Glauthier: Yes, I think there is. I think the Safe Drinking Water Act is an example that -- and that was passed back in the '70s when we really had a serious problem nationwide with just water supplies. And there was only regulation at the state level, so there was a national legislation put in place and that has done a lot to improve the quality of drinking water supplies. I think that's appropriate to be doing that here, too.

Greg Dalton: But how about on fracking oversight or is that something that's going to be just state by state?

TJ Glauthier: I think it is, I think, for example, transparency of the fracking fluids, the sort of chemicals alike, ought to be done in some way that requires that information is available to be used. And if there are trade secrets, there are ways in the federal system to protect that. We do that with chemicals and like for a lot of things. But the federal regulation gives us a much stronger base.

Greg Dalton: We have a couple of minutes left and I want to ask -- oh, Kassie Siegel.

Kassie Siegel: Well, just on the Bureau of Land Management's proposed rule on fracking and trade secrets. So what they've said actually is federal employees are prohibited from giving out a trade secret and it'd be a crime for us to do so. So we don't even want the information and they also -- I mean, they know this is in their proposed rule. It just came out. You've seen it and they say some states will make and it'll be an exception if the public interest in disclosure outweighs the company's interest in keeping a secret. But they're not even going to go there, the federal regulators.

TJ Glauthier: Well, there are a lot of examples of federal agencies, some cases being as bad as

anybody in the industry and that's why the EPA has been the regulatory agency that has been effective in these areas. And I think EPA's regulations ought to be binding of these other agencies, too.

Greg Dalton: Let's have our last audience question. Yes, welcome.

Audience: Yes. Hi. I'm a bit new to the fracking issue. Forrest DeGraft. Is there any talk of having or setting up either at the state or national level something akin to the Texas Railroad Commission, which used to limit oil production in the state of Texas to sort of smooth out the ups and downs of oil production? I'll take my answer offline, thank you.

Greg Dalton: TJ Glauthier.

TJ Glauthier: I'm not aware of anything like that. It seems to me that, right now, the gas developments are really being paced by individual landowners, leaseholders who can hire drillers to go and develop that. And that the market is the thing that, as Mark said earlier, is really moderating the pace right now because the prices are so low.

Greg Dalton: We have a couple of minutes left. I want to finish on a reference to a couple of movies that helped to really shame frame -- perhaps shame -- the debate around fracking. Mark Zoback, did you see Gasland?

Mark Zoback: I did.

[Laughter]

Greg Dalton: And did you give a thumbs up or thumbs down?

Mark Zoback: All 10 digits down. It's one thing to point to these important issues of the environmental impact to shale gas development. It's another to misrepresent the issue so, so dramatically and that was my problem with Gasland. The burning faucet had nothing to do with shale gas development, had nothing to do with fracking. Two years earlier, it was identified that that individual had drilled a water well into an area with what's called biogenic methane, methane that's just naturally occurring and it was just done for sensationalism.

Greg Dalton: Well, there was more than one person who lit their faucet on fire in that movie.

Mark Zoback: You can go -- well, you can go down the line. I think the important thing is to separate fracking from shale gas development. And shale gas development includes fracking, includes a lot of other things, trucking chemicals to the site and accidents, spills at the site, misuse of flowback water, injection of chemicals that should not be used, and a lot of them have been either abandoned or banned, and there is a movement toward greener drilling and greener fracking fluids. We need to do that and we need to do it more uniformly, and we need to regulate the fluids that are used and how they're handled. And we need complete and total disclosure; there's no excuse not to. So let's kind of identify where the problems are arising and then -- and seek the appropriate remedy and get off this addiction to coal that we have globally for electricity. We have an alternative and that alternative will get us to where we want to go, and that's to a renewable energy economy.

Greg Dalton: Kassie Siegel, was Gasland sensationalistic and distorting?

Kassie Siegel: I think Gasland is one of the most important movies of our time. I think it's galvanizing a movement and I don't think that Josh Fox misrepresented anything. He started covering an issue when he was approached by a gas company wanting to pay him \$100,000 for the

rights to his property. And I think he did an incredible job investigating that issue, telling people stories and letting people what was going on. And the thing with methane, no -- here we are in the richest, most scientifically advanced country in the world and we're still not capturing methane, even though it's easy and cheap to do. And in Pennsylvania, there was methane contamination of those wells. Maybe some of it's biogenic, but there's also studies that show that the methane was associated with oil and gas. So very, very, very important movie and we just need to keep building the movement because this movement against fossil fuels is part of what's going to get us to a rational energy policy. And it's going to get us to the greenhouse gas reductions that are just scientifically required in the next couple of decades. We need to start decarbonizing in the next couple of decades. Lots of people here have probably been to lots of fabulous talks here by top scientists about the urgent nature of the problem and what we have to do. Those are big changes and this movement against fracking is going to help get us there.

[Applause]

Greg Dalton: TJ Glauthier, last word on the urgency of decarbonizing the economy?

TJ Glauthier: Well, I think that part of what Kassie just said is the next couple of decades we need to be making changes, we need to actually manage this process so that the next couple of decades don't create even more problems. So I think the regulation, the transparency, the other things that are needed have to be done and we do have to continue to work at all the other ways of really making this energy sustainable and appropriate.

Greg Dalton: TJ Glauthier is former deputy US secretary of energy. Our other guests today at Climate One have been Kassie Siegel, director of the Climate Law Institute at the Center for Biological Diversity, and Mark Zoback, professor at Stanford University School of Earth Sciences and a former member of Secretary of Energy Chu's fracking panel. I'm Greg Dalton. Thank you all for coming to Climate One today.

[Applause]

[END]