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Edited Panel Transcript: Changing Energy Markets, a New Reality

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EDITED PANEL TRANSCRIPT

CHANGING ENERGY MARKETS, A NEW REALITY

ENERGY LAW AND POLICY IN THE ROCKIES
OCTOBER 14, 2016

L. Poe Leggette (moderator), Pat Day, David Lawrence, David Emery, Dr. Rob Godby, Ryan Lance

I. INTRODUCTION BY L. POE LEGGETTE[1] AND ALEXANDER K. OBRECHT[2]

Change is the only constant in life.
—Attributed to Ancient Greek Philosopher, Heraclitus

The changing energy markets of the early twenty-first century underscore the near-universal truth of Heraclitus's time-weathered theorem. Rapidly evolving technology, increasingly strict government regulatory initiatives, and shifting consumer demand, continue to erode the once-foundational principles of traditional energy markets. These forces have altered the ways exploration and production companies explore for and extract fossil-fuel resources, the inputs with which electricity generation companies produce power, and the options for individuals to power their everyday lives. And with those alterations has arrived a new reality in the energy markets, which is the topic that brought our distinguished panel together.

Dr. David Lawrence spoke on the uncertain future for oil and gas. Dr. Lawrence is an energy executive, investor, and advisor with extensive global experience across the spectrum of the oil, gas, and greater energy business. He is Chairman of Lawrence Energy Group LLC—an advisory and investment company with interests in emerging stage energy prospects differentiated by unique insights, technology, and innovation. Prior to retiring from Shell in 2013, Dr. Lawrence served as the Executive Vice President Global of Exploration and the Executive Vice President of Exploration and Commercial. His responsibilities over his career with Shell spanned exploration, development and production, strategy, liquefied natural gas, finance, investor relations, wind energy, acquisitions

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and divestments, and research. Prior to joining Shell, Lawrence worked for the United States Geologic Survey Coal Branch in Wyoming, prospected for uranium with Plateau Resources in Colorado and Utah, and taught geology at Yavapai College in Arizona.

David R. Emery spoke on the regulated utilities perspective. Mr. Emery is Chairman and Chief Executive Officer of Black Hills Corporation—a customer-focused, growth-oriented, vertically integrated utility company headquartered in Rapid City, South Dakota. The company serves 1.2 million electric and natural gas utility customers in 800 communities in eight states, including Wyoming. Mr. Emery has served as Chief Executive Officer since 2004 and Chairman of the Board since 2005. He also served as President from 2004 through 2015. Mr. Emery holds a B.S. degree in Petroleum Engineering from the University of Wyoming, a M.B.A. from the University of South Dakota, and he is a Registered Professional Engineer.

Patrick Day provided an update on the Clean Power Plan and its impact on the region. Mr. Day is a partner with the law firm of Holland & Hart, working out of the firm's Cheyenne, Wyoming office, where he has practiced law for the last 30 years. He obtained his law degree from the University of Wyoming in 1984 and represents many of Wyoming's natural resource and energy companies, including major oil and gas producers, refiners, power plants, and coal producers. Mr. Day represents Basin Electric Power Cooperative in the nationwide challenge to the Environmental Protection Agency's Clean Power Plan. In that capacity, he was one of the lead authors of the stay motions granted by the United States Supreme Court against the Clean Power Plan in 2016.

Dr. Robert Godby spoke on economic considerations of the new energy reality. Dr. Godby currently serves as the Director of the Center for Energy, Economics, and Public Policy and is also an Associate Professor in the Economics and Finance Department at the University of Wyoming. He previously taught at Laurentian University in Sudbury Ontario. Dr. Godby earned his Bachelor of Science (Honours) in 1990 from Trent University in Peterborough, Ontario; his Master of Arts degree in 1992 from the University of Guelph in Guelph, Ontario; and his Doctorate in economics from McMaster University in Hamilton, Ontario in 1997. Dr. Godby's research includes natural resource, energy, and environmental economics and policy; industrial organization; and macroeconomic policy. He authored the book The European Financial Crisis: Debt, Growth and Economic Policy and co-authored, with Stephanie Anderson, the book A Greek Tragedy and a European Odyssey: The Politics and Economics of the Euro-crisis. His research has helped inform State of Wyoming policy in the areas of energy development and environmental policy, most recently with a series of reports on Wyoming's coal sector and the potential impact of future greenhouse gas regulation on State of Wyoming revenues.

II. COMMENTARY[3]

POE LEGGETTE: . . . Dr. Lawrence, I'd like to start with you. What do you see in the mid and long term for local energy demand?

DR. DAVID LAWRENCE: . . . I think if I look at the mid to long term, I think it's useful to step back and take a look at the big picture. And that is that the world will continue to need energy, and the world will be driving towards less CO_2. And as you move and look at that energy transition that we have, recognize that these energy transitions will take decades.

So world energy demand is going to continue to grow, and what drives that? The main thing that drives it is population growth. And if you had to think of how many people are added to the world's population every week, what kind of number would you think? . . . [I]t's over a million. It's a couple of Wyomings a week are added to the world's population. And most of those people are being added to the world's population where there's the least amount of current electricity and power and energy use. So it's going to continue to grow and grow and grow in population and in energy demand.

We're going to see that not only in places like where the world's have-nots live in equatorial Africa, but we will see tremendous growth in energy demand as we see increasing industrialization, increasing manufacturing, increasing economic growth in places like China and India. So overall, the world's energy demand is going to continue to grow. I think it's going to grow fairly significantly.

You know, the numbers, frankly, are—there's a broad range. It ranges, I've seen numbers as low, and some numbers that have seen great increases in energy efficiency, as twelve percent in the next few decades up to fifty percent in the next few decades; but they all show, despite the efficiencies, despite electrification, energy demand continuing to grow.

Market shares of different types of energy are going to shift, and you're going to see this. You see lots of headlines. The renewables' increase in market share will shift, but you're looking at a shift in market share out of a greater sized pie. And as a consequence in absolute terms, I also expect that each energy source, whether it be coal or oil and gas, will continue to grow, and that's despite our best efforts in renewables, nuclear, hydro and efficiency and new technologies.

POE LEGGETTE: Mr. Day, there is concern among Americans and conviction within the Obama Administration that the current trajectory of fossil fuel use in the U.S. is risking a climate changing increase in global temperature, hence, the

[3] This transcript was edited for space and brevity.

so called Clean Power Plan. Tell us about the Plan's goals and the means it has selected to achieve them.

PAT DAY: Well, the primary regulatory policy goal behind EPA's Clean Power Plan is to reduce carbon dioxide emissions from the energy sector by 32% from 2005 levels. EPA's plan for accomplishing that is to essentially implement a nationwide renewable portfolio standard so that there's a forced shift in generation from fossil fuels, coal or gas, in favor of renewable energy, primarily winds and solar.

And the EPA is doing that by setting standards for existing gas and natural-gas-fired power plants that are lower than they can meet. It's not possible to meet, for example, the EPA's new standard for an existing coal-fired power plant. That's going to have the intended effect of setting a standard that's not possible of compliance, is to require power stations, coal-fired power stations and natural gas stations are going to have to stay in existence and are going to have to buy offsetting emission reduction credits that are generated by the construction of new renewable power.

So what's at the heart of the Clean Power Plan is a forced shift in the generation of electricity from existing coal and natural-gas-fired plants to the renewable energy industry. And the EPA projects that that's going to result in a substantial number of immediate coal plant closures around the country. It's already been enough to stop any investment in new coal-fired generation and even stop most of the investment in keeping up existing coal-fired generation. So the Plan's stated purpose is really just overtly to phase out coal-fired generation.

POE LEGGETTE: Suedeen Kelly mentioned at lunch the Plan has been the subject of challenges. What's the status of those challenges?

PAT DAY: Yes, we're right now involved in a litigation. There's been a challenge to the EPA's Clean Power Plan filed by approximately 90 industry companies, 27 or 28 states, and it's been fully consolidated. All of those cases have been consolidated into one proceeding. We argued the case to the en banc panel of the D.C. Circuit Court of Appeals two weeks ago. There were ten judges on the panel that heard the case, seven hours of argument.

. . . I didn't get to argue in this particular case. I argued in the predecessor case, but it was wearing to sit for seven hours of argument before the D.C. Circuit. . . . The court is clearly split, no surprise there, probably very firmly along partisan lines. It's hard to know what's going to happen. Our best guess is that there's no way a decision can be rendered before the fall election, and so the court is unlikely to try to do that.

There are going to be dissenting opinions, regardless of the majority outcome, that will be written and circulated within the en banc panel and debated amongst the judges themselves probably for some time. So our best estimate is that we'll get a decision from the D.C. Circuit Court of Appeals in the first quarter of next year, maybe Marchish, February, at which point, there will be cert petitions filed in the United States Supreme Court for sure, regardless of the outcome of the case.

The cert petitions are going to be granted on at least some of the issues, I'm sure, as well. And whether we go up to the Supreme Court in its current configuration with the four-four ideological split and an eight-member bench or whether we have by then a newly confirmed Supreme Court Justice to replace the seat vacated by Justice Scalia will have a huge impact on how the Supreme Court entertains and resolves the issues.

I think a lot of the D.C. lawyers and court watchers tracking the case really think it could well boil down to which presidential candidate wins the fall election and appoints the next Supreme Court judge.

POE LEGGETTE: And in all of the hullabaloo about the arguments and the reporting on what judge or which judge was asked what kinds of questions, what I almost saw overlooked is the fact that the Plan is still stayed, is it not?

PAT DAY: That's correct. We filed motions to stay the rule immediately upon its promulgation with the D.C. Circuit Court of Appeals, and that stay of motion was denied. Then we took the unusual step of going straight to the United States Supreme Court and invoking their ability to stay an agency rule pending judicial review, which the Supreme Court had never done before. We asked them to stay it, and they did with a five-four vote. Judge Scalia was still alive and voted in favor of the stay.

The way that we wrote our stay motion which was granted, the stay exists for so long as the number of days between the promulgation of the lawsuits and a final resolution at the Supreme Court of the final issue. So the legal effect of the rule has been stayed, but there's going to be a lot of arguments over whether the stay stays in place after the D.C. Circuit rules because if, by way of example, the D.C. Circuit upheld the rule but remanded a portion of it back to the agency, I'm sure we will have a bigger legal fight over whether or not the stay continues. So we have a stay at the moment, but we don't know how long it will last after the D.C. Circuit rules.

POE LEGGETTE: Professor Godby, let me ask you to assume that eventually the stay is undone and the rule is upheld pretty much as written. How is the Plan likely to affect our—the economies in our energy-producing states?

DR. ROB GODBY: Sure. So it, first of all, depends on what energy you produce. So clearly, if you're an oil producing state, it's mainly about electricity generation. So there's not much impact there. With respect to gas, renewables, or coal, though, it's a pretty significant effect. If you think about natural gas first, that one is probably positive. It depends on if you look at the near term or go out to 2030, for example.

So this plan has an eight year implement on the current time line, and as you just heard, that the current time line may be changed. However on the current time line—you know, it comes into effect in 2022—we have declining targets to 2030.

And I think a broad consensus of the crystal balls, which is really what it is, would suggest that natural gas in the immediate term benefits. So if you're a natural gas producer particularly where natural gas is used, you would see an increase in production. You know, that could—how much, we're not sure. Especially as you get out to 2030, it could be the case that even natural gas producers are hurt by this or at least they don't see the benefits that they might have anticipated because, by that point, you could see renewable generation.

So that leads to the next thing. Those states that have renewable generation could see a significant increase not just because of the Clean Power Plan but because of the incentives in the immediate term that have been renewed with Congress last December that have now put in place some certainty for the next five years with respect to renewable production tax credits for wind and investment tax credits.

So renewable certainly benefits, and obviously, coal, as you've already heard, is the primary loser. How much coal is affected really depends on what the circumstances are. So it will depend a lot on natural gas prices and how those are affected between now and then, and that is—there's a lot of debate about that.

Right now we have pretty low natural gas prices; in the recent past, very low natural gas prices. We're starting to see projections to see these rise. That may create incentives to build more renewables, which could then hurt, in the longer term, gas. But the short effect on coal is that it gets squeezed out of the market in one way or another, and the question is to what degree.

So nationally, if you look at projections and the effects of just the Clean Power Plan rules, right now the projections are looking at something like 15 to 30% reduction in coal production. That's just due to the Clean Power Plan, not including natural gas effects that are going on now that are also piling on, that would be piled on.

But it really also depends on where you are. So the Powder River Basin, being about 40% of the nation's production, would see the same sort of decline. It pretty much defines the national decline. If you're in some place like Appalachia though, regardless of whether the Clean Power Plan comes on or not, it looks like you're in trouble. That declines by about 20% regardless by a lot of projections and would have an additional 10% on top of that with the Clean Power Plan.

The Southwest is even worse. They're looking to really reduce production anyway, probably about a 25% reduction through time, but that would increase to about 45% probably under the Clean Power Plan. Oddly, though, there are some regions that might just hang on. So, for example, the Midwest, new technologies in mining there, mainly longwall, what's called longwall mining techniques. New cost efficiencies mean that you won't just get a reduction in coal, you'll also get a displacement of some sources for others.

So other regulatory programs like the [Mercury and Air Toxics Standards] MATS rules have made the value of the low sulphur and Wyoming coal less important because scrubbers have had to be installed anyway.

So it turns out that, you know, the Midwest may see a much smaller decline or could, in some optimistic scenarios, stay flat; but the bottom line is, if you're an energy-producing state and produce coal, you're going to see a significant decline. If you're a natural gasproducing state, in the near term, it probably rises but then moderates, and then the question becomes how much electricity growth occurs in the country?

POE LEGGETTE: Dr. Lawrence, this is a question I should more rationally have asked you earlier, but particularly in light of what Professor Godby just said, what do you see happening with the demand for oil, gas, and coal? Granted the Clean Power Plan is American, but I assume it's not unrepresentative of what other countries are going to claim to be doing going forward after the Paris accord, so what might we expect?

DR. DAVID LAWRENCE: Well, I think it's useful to kind of just start out with where we are today in terms of energy use, and then we'll talk a little bit about the impacts of things like the Clean Power Plan, Paris, and innumerable other regulatory and legislative actions taking place around the globe and then what that means, I think, ultimately to the demand for oil and gas and coal.

Fossil fuels, despite a lot of the rhetoric and a lot of the headlines that we have today, still supply over 85% of the world's energy. And of that, about a third is oil, a little bit less than a third is coal, a little bit less than a third is—than a quarter is natural gas. And then you take a big step down. And so by the time you get to nuclear, it's well less than 10%. I'm talking about primary energy supply, which I

will usually talk, versus just power. And when you get down to things like wind and solar, you're much less than 5% at this point in time.

So you have this huge, complex system that has all these issues of scale and complexity and interrelation that you have to deal with. And then recognize that, again, as I started off with, the world is still going to need energy. So what does that mean? How long do energy transitions typically take in this complex system and where you've got enormous terawatts of global demand?

Well, it turns out if you just look at the numbers, it's like sixty to eighty percent to sixty to eighty years to take it to twenty percent of primary market supply. . . . [T]here's a number of reasons for that. You know, there's incumbency. There's capital investments. There's sunk costs. There's infrastructure. There's unintended consequences of shifting from one source of energy to another.

So world energy demands continue to grow. These transitions take decades. And as a result of that, even though I support and I want to see as rapid a growth in things like renewables and I support nuclear and things like hydro as possible, given this demand, you're still going to see an increase in absolute terms in oil demand. It will be relatively flat in the U.S. to maybe even decline—talk about that later—in the U.S.

Most of that demand increase is going to be in Asia and the developing economies. Natural gas will grow quite significantly because, unlike oil, it has, of course, a major role that it can play in power and it will continue to grow rapidly but, again, in the non [Organization for Economic Cooperation and Development] OECD countries.

And then, I think interestingly enough, coal, despite all of these things, will continue to grow. And why? If you look at the number of coal-fired power plants—and this is even in consideration of Paris and things happening in places like India and so forth—it's over a million megawatts of coal-fired power plants that have been proposed and compare that all of the solar photovoltaic is about 665,000 megawatts. So coal will continue to grow.

So if you think about energy demand, always consider the complexity of all of these different systems and the scale, again, at which you're dealing. And the Clean Power Plan—we talked about that—will have an impact. It will have an impact in the U.S. It will mainly have an impact in coal, but it may have some unintended consequences on some other areas also.

POE LEGGETTE: Mr. Emery, you are on the frontline of the implementation of the Clean Power Plan. Traditionally, coal was the abundant, reliable, affordable source of energy for generating electric power. What's the potential impact of the Plan on your company's coal-fired generation?

DAVID EMERY: You know, all of our coal-fired assets are here in Wyoming. And so when you look at the impacts of the Clean Power Plan on an individual utility or an individual asset right now, it's extremely difficult. . . . [I]f you look at the provisions of the Plan itself, it's really the first time the EPA has ever really proposed to regulate the emissions not at the individual source but at a state average.

All right. That's one of the biggest single issues from a compliance standpoint that's very difficult to predict how that's going to work. It leaves it to the state to decide which resources run, don't run, which get added, which don't. You know, that's a whole different legal issue.

But when we look at it from our perspective, we have to make some gross assumptions on what that means for how Black Hills will comply when we have no idea what the state might decide. I mean, we've been at the table with the state, every state that we operate in since the very early stages of this and have been very active and, you know, filing comments and other things.

That all being said, we've made some gross assumptions trying to figure out what it means for Wyoming and South Dakota customers. Those two states use our coal-fired generation in Wyoming. So the assumption that we make there is that our fleet in Wyoming that serves South Dakota and Wyoming will have to comply with the average pounds of CO_2 per megawatt that's prescribed to Wyoming under the Clean Power Plan. That may or may not be true, but that's the only thing we can really assume today for planning purposes.

So that being said, our assets today consist of—there's four and one that we have a joint interest in, so five coal fired power plants at Wyodak Coal Mine in Gillette, Wyoming. Four of those are ours and operated by us, all 1996 or newer. Actually three of them are newer than 2003.

So they're state-of-the-art emissions control, some of the first in the country with mercury-scrubbing, all of those things. So ultramodern, ultraclean. They're air-cooled because there's no water in Gillette. By the very nature of being air-cooled, they're less efficient from a fuel perspective. So they emit more CO_2 per megawatt generated, just stands to reason; right?

They emit about 2,300 to 2,400 pounds per megawatt today. Wyoming's target under the Clean Power Plan is 1,300. Now, all that being said, we can deliver fuel to the pulverizers in the plant, storage and everything included for less than 80 cents a million BTU. So even in today's very low gas price environment, $2, $3, $4, whatever number you want to pick, we have a huge fuel advantage from a cost standpoint.

So the good news is if we look at all of that, we can comply using those assets with some significant investment and some changes. We'll have to add up to a couple hundred megawatts of wind in our system that serves Wyoming and South Dakota. And we'll have to [co]-fire [with gas and coal] either all of those units or convert one of those units to gas, but coal-firing them is roughly the equivalent of using about 30% natural gas and 70% coal in those facilities there.

That combined with the wind will get us in compliance and still be cheaper than the next cost alternative, which would be building combined-cycle gas plants to replace the coal, still a lot cheaper for customers. Just to give you a quick impact on what that means for cost to customers, we'll have to make a little bit of investment in each plant, probably $8 to 10 million a plant, not a huge number. We've got four of them.

The wind facilities will cost several hundred million dollars to add those, but the main difference is going to be fuel costs. So if we look at our plants today in Gillette, our average fuel cost runs about $13 a megawatt hour, 1.3 cents a kilowatt. If we use 30 percent gas, if it's $3 gas, that $13 becomes $24. If we use $4 gas, that $13 become $29. So you're looking at an all-in cost of that generation that goes from roughly 3.5 to 4.5 cents today to 4.5 to 6.3 . . . afterwards. That does not include the additional capital we'll have to spend. That's just fuel only, so pretty large impacts related to that.

And, again, a gross assumption is that we're going to have to comply with the Plan, and our system average has to meet the Wyoming average. Who knows?

POE LEGGETTE: Obviously, an impact on your customers. Do you happen to have sort of an average household cost on how these various scenarios might relate to what people pay annually or monthly in their fuel bill?

DAVID EMERY: Yeah, I don't have an average cost number. I would say if you look at your average residential rate for electricity all in, so not just the per megawatt charge but fixed charge and everything averages out, those rates probably run 10 to 12 cents today.

You know, you're looking at several more cents for fuel and probably another several two to three cents, something like that for the incremental wind and incremental capital.

So it's a pretty gross assumption but better than a 50% increase probably in the aggregate by the time it's over. And it could be quite a bit, you know, 60%, 70%. Just again, it depends on the specifics and how everything plays out.

POE LEGGETTE: Now, south of the border in Colorado, that state has pursued policies to mandate the use of renewable energy sources in order to incentivize

early retirement of coal-fired power plants. Have those policies affected customers in that state? Or to put it more colloquially, how is that working out?

DAVID EMERY: Good question. We have a bit of a unique set of circumstances in Colorado in that we've only operated our system there since 2008. We acquired that system from Aquila—basically serves southern Colorado—so Pueblo, Cañon City, Rocky Ford, that area.

There's one really unique circumstance there that doesn't really fit with what's happening elsewhere perhaps. And that is when we bought that utility, almost 70% of the power supply came from a long term contract from Xcel Energy.

Right as we were buying it, Xcel provided notice to Aquila that they were not going to renew that contract because it was an inexpensive contract and they were growing a lot of load. This was prerecession, of course. The load growth in the Denver, Boulder and that area was strong. They wanted to bring those back, those resources back to serve their own customer base.

So we were forced essentially in about a three year time period to rebuild the entire plant infrastructure to serve that utility, and it was a weird time because there wasn't the availability of good, long-term, low-price contracts in the market.

So my answer is going to have a twist. You know, it includes that. Because of the timing, we could not even consider permitting a coal plant. So we built a large natural gas fired—large for the size of the system—large natural gas fired, combined cycle unit, a couple simple cycle units at Pueblo, half a billion dollar investment or so. . . .

Then you start talking about the couple impacts of Colorado legislation that you referred to, two pieces of that—the renewable mandate, which is 30% by 2020. So 30% of all the energy that we sell to customers by 2020 has to come from renewable sources.

And then they implemented another piece of legislation called the Clean Air Clean Jobs Act in Colorado, which essentially says—it was a huge incentive and almost a mandate, not quite, for power producers who operate coal plants to retire their coal plant early and replace it with natural gas.

So we've done or are in the process of doing both of those. We've implemented the renewable standard in a manner that's kind of a just-in-time approach. So we have not been in a hurry to get there. With the construction of all the new generation in Pueblo, Pueblo is also one of the weakest economic areas in the state of Colorado, least ability to afford the changes there.

So we've taken a just-in-time approach on renewables. We're putting one more wind farm on that is actually in testing right now. It will be on by the end

of the year, and we'll be, oh, in the mid 20% range on renewables, which is about where we need to be now. We have one more wind farm to add to get to full compliance. We're in the process of building another gas turbine there to replace an old coal plant we retired in Cañon City, Colorado.

That plant was the only, what I would call, inexpensive resource we had left in generation fully for Pueblo. Fully depreciated, 50 years old, variable costs in fuel only, so less than a couple cents a kilowatt to generate there for customers. We had to shut that down prematurely and replace it with a gas plant.

All that added together says that in 2012 or 2010—excuse me—right before we brought on our new gas fired generation there, average rate in Pueblo was about 12 cents. Beginning this year, a little under 18 cents.

We're in a rate case right now, which the hearing is next week, to add this additional gas turbine in, and we haven't brought in the additional wind farm yet. So we expect a couple more cents there by the end of this year—a huge impact on customers; right? Customers are screaming, absolutely screaming. I spent the day Wednesday in Pueblo talking to stakeholders there. And, you know, it's an energy policy issue.

So the other thing that I think is being masked by all of the timing here is that those rates have gone up that much using a power generation fleet which I believe is exactly what the Clean Power Plan is trying to deliver for everyone; right?

Our system there is one of the only in the country that's all gas and renewables fired. That's what they're looking for. That's the objective. That's what the cost impact is. And it's been dramatically masked because the price of natural gas has gone like this (indicating [downward]) during the period of implementation. If we had stayed at $4 or $5 natural gas, these would be much worse.

POE LEGGETTE: So even in the low commodity price environment in natural gas, Mr. Emery, you've given me two real world examples where the lowest increase that I heard was 50%, and if prices go up for gas, so does that percentage, I guess.

DAVID EMERY: Absolutely.

POE LEGGETTE: Dr. Lawrence, let me draw us back to a national perspective. 20 years ago, we spoke of natural gas as the bridge fuel to a renewable energy future. 20 years later, have you seen the transition to renewable energy and concerns over climate change impacting American demand for oil and gas?

DR. DAVID LAWRENCE: You know, I think this might be surprising coming from me, but I think it will be greater than we expect that it will be. I think there's lots of forces that are shaping this. And I'll talk a little bit about maybe some of

those things that might drive that and then things like David was talking about, mainly, that price matters. That may move it in a different direction.

But we've heard a lot at this conference about things like the [Clean Power Plan] CPP, and if that happens, of course, that's going to make a drive that I think will enhance renewables but also I think with a couple of consequences for natural gas, depending on what the policy is towards new bills.

I think the federal tax incentives, if they're implemented and continue like this recent production tax extension, every time one of those is extended, you see a significant new investment in things like wind and solar.

The [Renewable Portfolio Standard] RPS, if that increases in what the states do and more states take that on, that will cause an increase. And then kind of this legislation by regulation and litigation, you know, to the extent that that keeps happening and other projects get delayed, that will move, I think increase renewables.

But I think you have to accept that there's also, within a growing amount of public opinion, a drive for more low CO_2 fuel. I mean, you can't stick your head in the sand and say, "That's going away." And it's not only in the U.S.; it's globally. So that public opinion will be something, I think, that's influencing everything that will happen.

Also, you know, if you look at the pace of technology introduction that's happened in the oil and gas industry through time, most recently by, I think, one of the greatest innovations of all, which was the revolution in shale gas and tight oil, but to think that those things will not be happening and they are happening in renewables, I think, is perhaps unrealistic.

And I think we'll see major technological breakthroughs in everything from battery storage to electric vehicles but recognize there's—it has a long way, a long way to go.

Just I'll give you an example. Right now, you know, the cost per kilowatt hour in batteries right now has dropped significantly down to somewhere around $200, 250, something like that. But that still is on an equivalency basis in vehicles to a barrel of oil of something like a $150 to 200 per barrel. So it still has a long way to go to improve.

So I think renewables are going to increase more than we think, but, again, I'd stress that I think also that oil and gas are going to increase in none other than I think it was Elon Musk who, he looked at this, and he said, . . . "If we didn't have oil and gas, our economies would collapse, and people would be starving to death."

Ask then so that's kind of a stark statement, but they're essential, and you can throw coal into that mix also. They're essential for what people need. So I talked a little bit earlier. Again, I think that overall there will still be growth and demand. I think that we should support and we should expect that renewables will increase as we go in the years and decades ahead.

POE LEGGETTE: So basically, as population will increase, so will reliance on all forms of energy.

DR. DAVID LAWRENCE: All forms of energy, the use of all forms of energy will increase. The world needs energy, and I just would sum up, who are we to determine that who are ultimately the energy haves and have nots? You wouldn't want that happening to you. I don't think the world's going to want it happening to them. So I think all forms of energy are going to increase.

POE LEGGETTE: Mr. Day, the advocates of renewable energy see it as the future of heating, power, and even transportation; but it is certainly not the now of heating, power, and transportation. And a lot is going to depend in the near term on how the Clean Power Plan plays out, what it will require of utilities. Do you see uncertainties and obstacles regarding compliance with the Plan?

PAT DAY: Yes. I think that the Plan is nothing but a big pile of uncertainties and obstacles. You don't have to go any further than understanding how EPA came up with its standards. The EPA historically has always developed performance standards for polluting sources by looking at technologies that go on the sources themselves and determining whether they're achievable across the country and have been demonstrated as a technology.

What EPA has done here is developed a standard based on computer modelling of the electricity flow in three major grid networks around the country on the assumption that electricity can flow anywhere in the grid that it needs to go and on the assumption that you can replace coal with renewables anywhere on the grid. In reality, that's not reality at all.

The EPA has not, for example, even attempted to quantify the amount of transmission infrastructure that will have to be built in order to get renewable generation load to the grid. It's not enough to build a wind farm. You have to build transmission facilities to connect the wind farm to the grid. And that's a demanding and expensive chore.

And as many of us here in Wyoming know, we've been trying for over a decade to build new transmission corridors for power with no success yet. So it takes on average 10 to 15 years to build a major new transmission system.

The EPA is imposing all these obligations that are supposed to start going into effect in 2020, which is not going to be enough time to build the infrastructure necessary to support the new renewable load EPA's aiming to get.

So the actual making this happen in reality is still very much unknown, and we don't yet have state plans that tell us how the states themselves are going to choose to regulate their sources. States can go with a mass-based approach which just measures the tonnage of CO_2 emitted or a rate-based approach which limits the emissions rate at facilities.

And until you know which of those two your state is going to be, you don't know what resources you have to change in order to meet. "Am I going to be turning my coal plant down?" That's a mass-based question. "Or am I going be buying emission rate credits from new renewable generation somewhere else and using those credits to average down my coal plant?" Those are two entirely different resource planning exercises, and we still don't know what any state is going to do.

POE LEGGETTE: Given those problems, do you think it likely industry is going to have to build new resources to meet demands?

PAT DAY: I think—and David can speak to this better than I—but from many of the utilities that I've talked to that are involved in litigation, they have made it very clear that they feel their fundamental obligation is to keep the power on for their customers, and whatever burdens imposed by the regulation, they'll make sure the power stays on.

But when you do resource planning with such long lead time and such uncertainty in the state about the law, I'm quite certain there are going to be a number of utilities around the country that, in order to avoid the uncertainty, will just build new generation they don't otherwise need so that they know they have something to provide their customers with power because it's very risky to say, "Well, when an emissions trading market develops out of the air"—because EPA hasn't created one—"I know I'll be able to buy the credits I need for the Dave Johnston Power Plant in Casper from that market."

There is no market yet. So you really want to be careful, I think you're going to find utilities building new generation, probably natural gas primarily, just to make sure they can keep the lights on.

So I think the big problem with the Clean Power Plan aside from the uncertainty is it's going to be enormously costly. . . . David's example is the most favorable one I've heard. Many utilities are privately estimating costs are going, at a minimum, to double and probably triple your bills.

POE LEGGETTE: Mr. Emery, Mr. Day has invited your thoughts on the points he just made, and now so I do. What do you think?

DAVID EMERY: I agree with that. I think obviously the renewables are going to be absolutely necessary. Especially in a state like Wyoming, there is no way you can get to an average rate of 1,300 pounds per megawatt without adding wind, which is zero, if you've got coal at 2,000.

And the way the whole formula works, which is very complex, you can get credit for adding renewables, but you don't get credit for adding lower emission fossil sources. So you can't average down by adding gas plants. They don't allow you to do that. You can average down by adding wind farms. They allow you to do that. But if coal is at 2,000 and gas is at 1,000 pounds, you can't add gas and average your way down. That's not allowed in the way the rule is written. So you have to add renewables to average down. So by nature, you have to do that.

The thing that I'm most concerned about in this whole thing is there's a public perception that these resources that we're talking have the same duty—right?—they're interchangeable. They absolutely are not interchangeable. They can complement each other, but they're not interchangeable.

You can't replace coal with wind or solar unless we have a miraculous improvement in energy storage technology. Someday, I agree with David, we'll keep making progress. That's probably decades off at best. So in the meantime, what happens for us is we have to plan whatever we need for generation resources to meet our customers' load. And not only do we have to plan for that, we're obligated to do that.

We're obligated to not only meet what we think the forecasted load is going to be, but we also have to have a margin on top of that that's mandated for us. And we sometimes share that margin with the neighboring utilities and others, but we have to forecast what we think that peak demand is and have excess on top of it.

Wind or solar, either one, we really can't count all of the megawatts towards that calculation. So if our customers need 100 megawatts and we have 100 megawatts of wind, as a rule, we can only count about 10 megawatts of that wind as being a resource that we can count on to meet that 100.

And 10%, I think, is a high number, but that's the instructions we're getting from our commissions that, when we do resource planning, you give renewables about a 10% credit for capacity. And that's the difference. There's a capacity market, as Suedeen said earlier, and an energy market. Capacity means it will be there 24/7; energy is . . . available right now. There's a big difference. Planning, we have to plan for capacity. If we can't count renewables for much capacity, we have to have gas to back up almost every megawatt. So 9 out of 10 megawatts of wind

or solar that we add, we have to have gas or coal to back it up or nuclear, which we don't have in our system.

Right now, I think that impact has been masked because there's only a few percent of renewables in our total system today. So there's enough generation because of all the cheap coal we have, [and] the new gas plants we have to cover that capacity shortfall.

If we shut all those coal plants down, that really worries me because we're going to have construct new gas plants, not only to replace the base load element, but, you know, deal with the unpredictability of the wind and solar. And that's really where it comes down to.

I'll give you a great example. Cheyenne, Wyoming, if you drive on [Interstate] 80 from here to Cheyenne, you'll go past a couple wind farms that we take all that energy into our system for South Dakota and Wyoming. Roughly 5, 6% of our total energy is renewables in that system right now. The last four times we've had new peak loads in Cheyenne, either winter or summer, the top load that we've had to date, we've had either 0 or 2 megawatts of output from a 60-megawatt wind farm at that peak.

If you think about it, it makes sense because the peak load occurs when it's either 30 below 0 and dead still or a hundred degrees and dead still; right? But we have to plan for that, and we can't count on the wind to be there.

So, you know, the long answer to your question, I think we're going to need the wind and renewables, but I think we're also going to have to really deal with how we back those up. We've had the luxury of excess inexpensive coal and nuclear to cover that. If you see an increase in retirements of nuclear, like we talked about already today, and an increase in the pace of retirement of coal plants to comply with the Clean Power Plan, that's going to shift that risk even greater than I think we're really even anticipating today.

POE LEGGETTE: Professor Godby, Mr. Day has introduced me to a new phrase "rate versus mass." Can you explain that phrase, the issue, and what does that issue mean for coal-producing states?

DR. ROB GODBY: Right. . . . So the simple way of saying this is mass-based standards are the way we think about greenhouse gases; right? How much has actually been emitted? And why we worry about that is that greenhouse gas is—the greenhouse gases are cumulative. In other words, it's not how much we're emitting right now that causes what we understand is human induced climate change, but how much we emit over time. So we have to keep an eye on how much we're emitting and how much it accumulates in the atmosphere.

So a simple measure, by 2030, Wyoming has to produce no more than approximately 33-and-a-half million tons of CO_2 per year. It's hard to imagine that. You can't picture 33-and-a-half million tons of CO_2, but that's how you measure it. So it's kind of easy to get your head around.

But the traditional way we've measured emissions when we're talking about pollution is a rate, and this is in part because the emissions that we've worried about in the past are not cumulative. The concentrations now are what matters.

And we have a natural dissipation rate in the atmosphere. So, for example, sulfur dioxide eventually turns into acid rain, comes down, and it's out of the atmosphere. So what we worried about was how much was produced per unit of electricity. Part of this is that the Clean Air Act was used to define the Clean Power Plan. That was all we had. And so to go to some comments a little while ago, I mean, that's where we can't do anything about it. It has to do with politics.

Certainly economists would probably be the last people to say that the Clean Power Plan approach is the best way to go about this. But, you know, from what EPA considered a legal standard, it was the only way to go about it. So we were originally defined in rate, and what that means is the amount of CO_2 per unit of electricity produced. And Dave's already talked about it. Wyoming in 2030 will have to meet a rate of 1,299 pounds per megawatt hour. He said 1,300, so who is going to quibble about a pound?

But the point is there's a couple of points to that. One is, first of all, just thinking about this, that is not an absolute cap on CO_2. It depends on how much electricity you produce, how much CO_2 you put out there. So to some people that's problematic although, realistically speaking, we can ballpark how much electricity we're going to need in this country. So that gives us an idea of what that means one for the other.

But more fundamentally, what does this mean maybe working through this as states decide how to implement these rules? You know, we could go with a very heavy handed approach where the state actually decides which resources to use and which not to use.

In that situation, a mass-based approach doesn't pose a problem because you can just say, "We're going to use a number of coal-fired power plants or whatever. They will be allowed to produce this much electricity that produces this much units of CO_2."

. . . [U]nder a rate-based rule, as you've already heard, coal-fired power plants cannot produce at that level under current technologies unless we find some form of carbon capture, and, you know, you wouldn't want to use that right now because it's just too expensive.

So absent some technological breakthrough, what this means is that every time—let's just use a very inefficient coal-fired power plant. Imagine that it runs, say, 2,600 pounds per megawatt hour, and some have, and some currently do. That would mean that for every megawatt hour you produced, you'd have to have another megawatt hour produced by a zero emission plant to create kind of an average at 1,300.

And so that's what we've already heard about. It means that you're going to either have to control the portfolio that you have of production at a point in time or create some incentives such as markets that would basically force that to happen through regulation and allowing market choices as opposed to an overall choice.

So that's what rate mass means. We're kind of stuck. One other thing I'll say is that, originally, the Clean Power Plan came out with rate-based standards only, but CO_2 controls in some existing markets are done in mass. So early on, there had to be a calculation. "How do you do one to the other when they're so fundamentally different?" And the EPA wrote some guidance to that effect in the comment period of the first revision of the Clean Power Plan, and then the second version of the Clean Power Plan actually offered two different standards.

So the first thing, as you've heard, a state needs to do is to decide what standard they're going to regulate under, and then based on that, that basically determines your dance partner. So if you're going to cooperate across states to try to capture cost savings and use larger systems to produce electricity because, let's face it, electricity doesn't stop at the borders, your dance partner has to be somebody who has similarly decided to regulate. And so there's a coordination problem, first thing, of what states will do, and depending on what states do, then that determines how you might go about trying to meet compliance.

POE LEGGETTE: I hear lots about cost. Is there a role for the free market in reducing costs of compliance?

DR. ROB GODBY: Yeah, actually. That's a good question. The EPA from the very beginning, certainly with the second version of the rule, they presume that there will be a market-based approached to this.

So it's presumed under the mass-based standard that states, for example, could have an auction. So one way to encourage least cost compliance would be to auction these permits to what are call the "covered sources," those that are fossil fueled. And obviously, if you want to minimize your cost, you buy as few of these permits as possible.

So they would be auctioned. That could generate a revenue source for the state. Clearly in that situation, a coal-fired power plant is going to have to

purchase and approximately double the number of permits that a gas-fired one will. And that's going to create some basic economics that makes coal-fired power plants either far less competitive on a large grid, or you're only going to have half the production from coal-fired sources.

On the other side and the rate-based allows other sources to come into effect. So in that case, if you're a wind generator and it's been built after a certain date, your electricity production actually creates credits because you're underneath the standard.

So if the standard is 1,300, you know, every megawatt hour you've created is worth 1,300 pounds, and so you can sell that credit to a coal-fired generator. And there's some dynamics in the markets under different simulations, and I've done some work on this. And, trust me, you probably don't want to hear it at 4 o'clock in the afternoon. But the bottom line is, oddly enough, under some circumstances, wind and coal can become some strange bedfellows.

Coal's primary concern, I think, is natural gas if you want to maintain those resources. And I look at it from the State of Wyoming's interest. We try to—we want to maximize the value of our coal resource, and that means protecting coal, if possible, while still meeting these standards.

And a rate-based standard could allow you to do that assuming others—actually, really what matters is that others adopt a ratebased standard. We only use 3 percent of our own coal. So what we'd want to see is more wind that could create credits to support coal generation and still meet the standard and avoid building out a lot of gas. Under a mass-based standard, it's much more likely that you see a larger buildout of gas, and that phases out coal, and that reduces the value of Wyoming's coal resource.

POE LEGGETTE: Dr. Lawrence, we've heard that the Clean Power Plan is intended to drive choices among primary sources of energy. What do you think will be the primary criteria that will drive choices among renewables, fossil energy, nuclear?

DR. DAVID LAWRENCE: You know, one of the things I think is that you have to choose what the problem is that you're trying to solve. So if the problem that you're trying to solve is you want to provide affordable energy, you want it to be reliable, you don't want the lights going out, you want to provide CO_2, to lower CO_2—you don't have that many options. But in many places, we act as if we do have those options. So we want our cake and eat it too. And the reality in energy is there are no perfect solutions. There aren't. There are good solutions. There are okay. There are no perfect solutions.

So people—for example, Germany is a great example of where one of these experiments has taken place, but it's not really an experiment. They introduced

it. It's part of this energy agenda. And, again, one of the things, again, a major significant increase in renewables and wind and even solar in northern Germany. And at the same time, they phased out actually more than phased out—a lot of their nuclear power. But they didn't fully take into account the baseload requirements and the reliability requirements.

So what happened, the unintended consequence? They started burning more brown coal and lignite, and consequently, even though they had this big increase in renewables, the CO_2 has actually stayed fairly constant. And that's because they've tried to address nuclear and not really thought, "I want reliable, and I want affordable, and I want a lower CO_2."

I love Suedeen's example of New York. You know, so you can decide whether you're going to be for fracking and cheap and abundant natural gas, which will be cost competitive and can stay down at low prices and ultimately lower CO_2. And it has resulted in the greatest reduction in CO_2 of any of these new technologies that have been out there and often overlooked.

Or you can ban fracking. You cannot put in a pipeline to a place where you're burning oil in the northeast, and your CO_2 will stay high. You'll increase. You have to decide. What is the problem? And I would submit to you that the problem is to provide affordable, reliable energy at a cost that consumers can afford while lowering CO_2 and to consider that. I think that price absolutely matters.

I love the quote from Edison which is "We will make electricity so cheap that only the rich will burn candles." I thought it's a great quote because, if you think about what actually drives the behaviors, if you can actually lower these prices to that point, I think that will be a driver.

If you don't believe that, that price matters, again, I think you're seeing it right now in all of the examples that we've talked about with increase. Just look at what's happened with increased—lower oil prices has a big impact on me and how that's lowered gasoline prices and what that's meant to some important transportation indices.

So what's happened? Prius sales fell 11%; SUVs went up 10%. Miles traveled in the U.S. increased significantly. The miles per gallon actually decreased, and so we've been on this upward trend. The price lowers, and unless you have the luxury of affluence so it doesn't matter—and most people don't have the luxury of affluence—price still matters. So we need to keep this very—and I think that's going to drive the choices.

Policies will matter. Public opinion will matter. I think ultimately, accessibility and reliability. If you've ever lived in a place where the power's been off for a week or two weeks or there has been no power, I think people understand that. But

public opinion—and I think rightly so—will move us towards a greater mix of renewables.

POE LEGGETTE: Mr. Day, while you are the lawyer on the panel, it has been Dr. Lawrence who was thrice in the law and unintended consequences. Do you see . . . consequences arising from implementation of the Clean Power Plan?

PAT DAY: Yeah, I don't—I'm not a utility planning or resource planning expert, but it's not going to be possible to implement the system as quickly as the EPA has ordered just because it takes so much time to build the necessary infrastructure, and that alone is going to make this very difficult to do.

So I think we're going to see an unintended increase in the construction of new natural gas generation which is going to be forced to be built to back up, as David Emery was explaining, the wind. So you add wind, but now you've got to add gas to back it up.

And so utilities are going to be making very expensive choices in order to pursue these policies that are not part of the calculus that EPA has generated to come up with its numbers. So I'm not entirely sure that, even if it all goes as expected, that the actual reduction in CO_2 is going to be nearly what the EPA anticipates.

And, you know, you're going to be—another thing that's going to happen—we're already seeing this in social media that I follow—the Clean Power Plan is going to be used by environmental groups who wish to target specific projects they'd like to shut down. So building new infrastructure to support, for example, a coal-fired plant in a particular location that's disfavored will generate litigation to stop the infrastructure building in order to force the plant closure.

So there are already groups planning strategies to use the burdens on utilities caused by the Clean Power Plan as leverage to make it even more expensive and force choices to be made on a cost basis. Those plans are already being laid. So I guess you've described the Clean Power Plan as also the full employment lawyer plan, but that's what it looks like is coming down the road.

POE LEGGETTE: Mr. Emery . . . You've heard from fellow panelists, if I could quote their views as succinctly as I can, that renewables can play the major role that EPA is trying to mandate only when they become abundant, reliable, and affordable. In the states that you serve, when might that be?

DAVID EMERY: And that's a good question, and I have absolutely no idea. You know, the reality of it is there's several factors there that we've been talking about for an hour and a half here. It really boils down to several things. I think right now, as I mentioned earlier, we have the benefit of gas prices being low, and I do

think that's helped with some of these issues, making them a little more palatable from a customer expense perspective.

We also have some pretty large subsidies—tax credits, production tax credits, investment tax credits, and net metering—which subsidizes the rooftop solar, things like that that are I think are masking the true costs of renewables right now.

So when you look at wind, for example, you have a 2 cent-per-kilowatt federal tax credit for that. All of us pay it, but when you see the numbers on what wind costs, they don't ever add that number in; right? So, you know, I think if you just look straight up at what is the real all-incost, including firming and backing up and all of that, we've got quite a ways to go, a long way to go.

We don't have a viable energy storage technology today that's even remotely economic at a large scale. Small scale, yes; large scale, absolutely not. So until we get that going, it's going to be very difficult. I don't know how you define "affordable;" right? But in comparison to anything people are paying today, we're a long ways off.

The ideal scenario—and I think Suedeen talked lot about this earlier, and it also came up in several other talks today—that in order for this really to work as what I think the EPA has envisioned it, you really need to be able to interconnect very large areas of the country together that have varying weather patterns, that have varying sources of generation. You can share the ability to back up the wind. This part of the country, the wind's blowing; this area, it's not. You know, you can share those resources.

In order to do that and do it adequately, you have to expand substantially the gas and the transmission infrastructure in the United States. And as we heard from some of the other panelists today, siting transmission is an absolute nightmare. We've seen what is happening on pipelines today. So I just don't see how you get to an affordable system that really works if you can't design it in an aggregate that's more efficient; right? And I don't see the ability to get that infrastructure sited and built to really solve the problem.

So as individual utilities—and I think Pat made this comment—we're all planning to deal with our own problem, largely. I mean, we might be talking to the next door neighbor or whatever. It's a lot more expensive that way than dealing with a big, say, western system problem. But we don't have any choice because we can't completely interconnect.

We've had the Energy Policy Act of 2005 [that] was supposed to deal with these transmission siting challenges. Right, Suedeen? We haven't seen any get built anywhere—right?—especially across federal land. That was eleven years ago. So absent that solution, I have no idea when I would say it would be affordable,

which, again, I would define as being somewhat comparable to what people pay now or maybe a little more. I don't how you can predict that.

POE LEGGETTE: Thank you. Let's open it up for questions. . . .

AUDIENCE MEMBER: . . . My question is at the international level, and I hought I might direct it to Dr. Lawrence initially but welcome any of the other panelists' feedback. It relates to climate change and the Paris Agreement. My understanding is that the European Unions' ratification of that agreement last week is going to result in its entering into force in about a month, the front end of November.

I'm wondering if, Dr. Lawrence, you could talk about some of the major implementation issues you see with the Paris Agreement once it enters into force, particularly those implementation issues that you think are most germane to the focus of this panel, changing energy markets. Thank you.

DR. DAVID LAWRENCE: I think many of the implementation issues associated with Paris and internationally will be the kinds of things that we've talked about in practice, that we see here. We recognize and recognize that internationally, again, with the different agreements that individual countries have made that some countries already have a head start on that. So they may have less of a way to go, for example, in shifting from coal-fired power plants to natural gas.

Some of them will be implementing, and they probably have a greater public mandate to implement a larger source of renewables than we have here in the United States. So I think you're going to continue to see that, and, in fact, you are seeing that growth very rapidly, particularly in the European Union.

I think the greatest challenge that you'll see in the Paris Agreement is compliance ultimately, despite the rhetoric, in places like China and India that, again, as I mentioned earlier, there's going to be a tremendous amount of coal-fired power plants put into India. We'll see how well ultimately that complies with the agreements that have come out of Paris.

Then, importantly, I think will the financing become available for those third world countries that financing this energy transition has been a major issue in obtaining the necessary capital and whether that capital will ultimately find its way to where there's not necessarily a secure source of return will be a driver that you see in the Paris Agreement.

Having said all of that, it will make a difference. It will drive changes, and those changes may not be at the pace that countries agree and update, one of the benefits of the Paris Agreement, but it will drive change. But they will phase it,

and we've talked about some of the consequences, many of the things that we've talked about here in the U.S. directly today.

AUDIENCE MEMBER: This question similarly is initially directed to you, Dr. Lawrence, but also to any other panelist who would like to answer.

You used the example of consumer responses to the price of gasoline. You know, as the price goes up, Prius sales increase; as it goes down, SUV sales increase. Is there going to be a similar response, or is there a capacity for a similar response as we see the price of electricity increase?

DR. DAVID LAWRENCE: In fact, again, I think it was shown earlier today you actually have that you do get demand response. And, again, David or you guys would be better positioned, but I do think, as you see an electricity increase in price, you do see a response in the demand requirements for that. And you have seen, for example, lots of efficiency measures that come into place.

The one—and David, so I'd invite you—but I do want to say one thing. You know, there's this thing that's called a rebound effect actually also. And one issue is as we make things more efficient or cheaper and you mentioned LED lights, what happens is, as they become cheaper, people use more lights, and so the electricity demand can tend to stay the same.

So there's all sorts of behavioral issues one of which is—I'm not sure it's called the rebound effect, but something like that—those are the kind of things we have to contend with. . . .

DAVID EMERY: I can just give you a quick example. I mentioned that, literally, I spent Wednesday in Pueblo, largely meeting with our large customers, most of whom are industrial customers. I talked earlier about the difference between capacity and demand; right? Those large customers have both charges; right? So they have to pay for the maximum peak that they use, and then they pay an energy charge for every kilowatt hour they use.

That peak really matters, and it's expensive to us because we have to plan basically to add all of those [customer peaks] together. And they might—that might only be for five minutes a day, but we have to be able to meet it. So it's expensive; right? It means a new turbine might only run a few hours a month, but we have to have it. So we charge them for that. One of the regulatory concepts of being governed by the public utilities commission is that the customers pay for what they use.

So if you're a residential customer, part of the system is designed to serve you. If you're an industrial customer, there's other parts of the system like peaks and things that we have to have backup generation, other things—you should bear the

cost of those. They shouldn't be socialized amongst all the customer classes. And that's a key ratemaking concept that we comply with.

So back to the industrial customers, this demand charge is having a huge impact on them. The energy cost is expensive, but the demand charge is really big. And we have a team of engineers and energy services professionals that literally all they do every day is work with large customers on how to reduce their overall consumption, but in particular in Pueblo now, it's shaving that peak.

You know, it's things like sequencing the startup of equipment. You know, it's all of these things they can do to manage their energy, both the peak and the average consumption. You know, the higher the price is, the more they need that service, and for them, it's a big issue.

We listened to some of them yesterday. You've got aerospace companies and others that have manufacturing. In Pueblo, they have another factory in a neighboring state that their costs might be cheaper. Well, if they want to stay open, they have to manage the cost differential between their plant and the one next door. So the way they do that is by tempering their demand and consumption, which we try the best we can to help with that, but the higher the price is, the more you're going to see. . . .

AUDIENCE MEMBER: . . . I just have a question about renewables. You've been talking about reduction on a large scale, utility scale, and I'm wondering as much as this proves that computers can turn into what you might think of as the future of using distributed energy sources, whether at the community or household level.

DAVID EMERY: I can take a stab at it. Anyone else can too. You know, right now, I think there's a substantial cost differential. I do think that there's some advancements being made, and, again, depending on what overall prices do, there's going to be situations where distributed generation makes sense.

Part of that was what I was talking about earlier. We may have trouble backing up, you know, with some of these mandates, backing up the renewables and backing up the supply. Some of those customers will put their own facilities in to do that if they're concerned about our ability to deliver. So I do think that's going to happen. Right now I would say they're certainly more expensive than our system in general, but, again, as you see increasing pressures, you know, you're going to see those numbers getting closer together.

So distributed generation has some viability. The obvious things you see now today as a consumer and the one that's getting the most attention these days is residential solar, private solar on your rooftops. Edison Electric Institute did a study of trade organizations for all the electric utilities in the country, comparing

the cost of solar on individual private homes versus large size solar farms owned by utilities, more economy of scale, whatever. The cost differential is double. Double.

So that's how far off we are on that piece, at least on a small scale, residential type distributed gen[eration]. But, again, the technology is changing fast. I do expect that to change over time.

DR. DAVID LAWRENCE: I'd just add to that, you know, I think that photovoltaics and the number of rooftop units and so forth, if you look at the numbers that have been installed, it's an extraordinary growth. Hundreds of thousands have been installed. The issue, I think, primarily in terms of overall and what it means for our power sector is still a matter of scale. The growth rates are amazing. If you look at the percentage of electricity that it's providing right now, you know, you can hardly see the line on the plot.

So that will continue to grow, and I think there's other—people like the autonomy of this system. I mean, I think there's other things that drive people to this, and I think you're going to continue to see it grow rapidly. But I think always recognize that it has to grow enormously for it to make, in the next decade, a kind of the difference of the kind of things we're talking about. . . .

SUEDEEN KELLY: Thank you. I had a follow on question to that transportation question. I learned last week that it appears that in 2016 greenhouse gas emissions from the U.S. transportation sector will be significantly greater than the greenhouse gas emissions from the electricity sector, which if your goal is to lower greenhouse gas emissions, you would think maybe there should be a policy that would move cars from gasoline driven to electricity driven at least for a while until you increased the electric demand.

But on the other hand—so I guess I'd like to know your response to that. If you were an electricity utility, would you want that to be figured into your Clean Power Plan if you could provide incentives to increase electric, the electric sector of the transportation sector? Or is it really just an unsolvable problem unless and until we incorporate the carbon externality across all sectors?

DR. DAVID LAWRENCE: I'll start with kind of a base of electric vehicles and kind of that rate of market penetration right now and then maybe talk about—it is interesting that if everything goes electric, electric power demand will increase significantly, and that can be addressed. But if you look at right now in the U.S., we will probably finally get over the hurdle of a million vehicles sold that are hybrid or that are plugin electric vehicles. And if you look at how many vehicles are sold worldwide, actually that's a million worldwide. If you look at how many are sold worldwide, it's over 80 million vehicles, so one eightieth of that. Now, it's growing, and it's going to continue to grow rapidly.

There's already a car park of well over a billion vehicles there, and the biggest challenge is that, you know, when you sell, you know, an F150, then what happens is it stays on the road for another 10, 11, 12 or more years. So that those current sales and that rate of market penetration will naturally limit how rapidly we can move to electrification of the fleet.

But I think also—and again, what you're going to see in addition to that, and some announcements were made today, is it's not only electrification, it's not only hybrids. I think you're going to see some very significant increases in the efficiencies of standard internal combustion engines and things like the compression ratios and things that were talked about today, and that will drive our overall efficiencies. But how all of this will impact and get moved directly into the power sector, I'm very interested in that response.

DR. ROB GODBY: And one thing to keep in mind, that statistic, which is surprising that electricity will produce less greenhouse gas emissions, was really driven by the use of natural gas. Right now that is artificially low. We had some really low natural gas prices that a lot of people don't think are sustainable. The other thing I'd say is that the current output from the transportation sector is going to change significantly. You just heard that. [Corporate Average Fuel Economy] CAFE standards kick in that are incredibly high relative to what our current fleet economies are now. We'll see that.

And then you add a third thing which is where electric vehicles are currently on the margin. There are potentially some really disruptive things just around the corner. For example, this coming month, GM will introduce their Bolt vehicle, which has a 200 mile range, 300 miles if you don't use the really strict EPA standard, and it's going to cost a little over $30,000—37, I think—without subsidies.

And that seems to be the critical threshold. If you can get a vehicle that's cheap and can go over 200 miles, that suddenly avoids a lot of people's range anxiety, and we've already heard this. There's a lot of pent-up demand to do something, and we really can't underestimate how consumers' preferences are going to drive this as well. We've heard a lot about the supply side, but consumers really want to make a difference. And to your point about distributed generation, many people will pay if they think it will work.

And so one of the things I'd say is that this is a really complex system with a lot of moving parts, and we're looking at what we think are short time scales in, you know, the electricity system are decades, and there's a lot of time for a lot of change to happen, not to mention these technology and cost changes that just keep coming.

So I guess the one thing I'd say is the range of uncertainties is wide, not only in what we don't know with respect to operating the system the way we

traditionally do, but right now, there's just a confluence of new ways of doing things. There's a lot of disruptive things that are happening at the same time.

DAVID EMERY: You know, it's hard to predict what the impact will be obviously on power supply, but certainly if you're concerned about taking emissions out of cars proper, electricity seems to be the way to go. But in order to not just transfer emissions from transportation to utility sectors, it requires the technology, the changes we've been talking about.

So the one thing I would say is an almost certainty, the more you switch the transportation sector to electricity, the more you're going to exaggerate the issues we already talked about when you talk about compliance with the Clean Power Plan. It's going to place that much more demand.

Now, there are some features of electric vehicles and things that you can alter charging times and things that might not be—you know, it's not going to be a direct impact because they can charge at night, for example, when we don't have a peak system wide. So that will make that planning a little bit easier as an incremental additional need to supply electricity. It will be a little easier to supply than what we supply today, but it's still going to just exacerbate that challenge, I think. . . .

TEMPLE STOELLINGER: So kind of off the last point which is consumers want to do something and maybe ending the conference on a high note, Dr. Lawrence, on wind data in your keynote you talked about this really innovative thing that you're personally doing, which is putting a carbon tax on yourself, and I'm wondering if maybe we can end with you talking about what that looks like and . . . .

DR. DAVID LAWRENCE: Well, thank you, Temple. You know, for a while, I've looked at all different forms of carbon pricing and cap and trade and so forth and looked at all the pros and cons and how long it's taken actually to get anything moved to price this externality.

So I decided actually that I was just going to actually doing something, and I was just going start with me. So I put a carbon tax on me, and I've written this up a little bit. But what it does is—and I put a challenge towards myself in a target every year that I'm going to increase my efficiencies in how I use energy every year and reduce it by X percent a year. It was 10% this past year. I calculate the footprint of how many tons of CO_2 that I produce, and I provide a mechanism that you too could do that. And it turns out that the average American uses about 17 tons. They use about less than that, less than 10 in Europe, and I use more than that because I travel a lot.

And then I've imposed—you can choose a carbon price that you want to put on it, and I said you could use what a lot of people are using, anywhere from 5 to

60. Five is low; 60 is high. I put a carbon price on me of $40 a ton. Then I take that how much carbon I've emitted. I pay my carbon tax based on the amount of carbon I've emitted times my $40 a ton, and I use that. And most of that savings, by the way, I can pay for that by the efficiencies that I've improved in during the year. And then I take that money, and I invest it in clean energy, and I get that return. So in a sense it's revenue neutral.

I also have a real passion—this is my one plug, so thank you for this, Temple—in addressing energy poverty around the world. So I also allow myself to take that revenue from that carbon tax and invest it to address energy poverty where so many of the people of the world so desperately need it. So you can learn more about it, and I'll let Temple provide that information.