

Can California Get to 100% Clean Power?

<https://www.climateone.org/audio/can-california-get-100-clean-power>

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Greg Dalton: From the Commonwealth Club of California, this is Climate One, changing the conversation about America's energy economy and environment. I'm Greg Dalton. Roughly a third or a quarter of the electricity that runs California's homes and businesses now comes from renewable sources, solar, wind and geothermal. That will rise to one-half for the next 15 years making California one of the cleanest economies in the country. But clean energy advocates say Governor Brown in the California legislature could be more ambitious and shoot for 100% clean electricity. That is technologically possible they say. It would help fight climate disruption that is amplifying, amplifying but not causing severe droughts, floods and fires around the state and country.

Over the next hour, we will explore California's clean energy push with our live audience here in San Francisco. We have three guests on the program who are deeply involved in this debate. Mark Ferron is a member of the California Independent System Operator, that's the agency that runs the electric grid, the powers our toys and toasters and just about everything else in our connected lives. He is a former member of the California Public Utilities Commission and disclosure: he is a donor to Climate One. Mark Jacobson is Professor of Civil and Environmental Engineering at Stanford. He is on the board of the Solutions Project, a group advocating for 100% clean energy across America. The group is backed by Google Chairman Eric Schmidt's family foundation and actor activists Leonardo DiCaprio and Mark Ruffalo. Steve Malnight is Senior Vice President at PG&E, California's largest electric utility. He's pinch-hitting here today for PG&E President Geisha Williams who will join us another evening on a future date for another conversation. Please welcome them to Climate One.

[Applause]

Mark Jacobson, 100% it sounds like a big hairy audacious goal; tell us how California could get there.

Mark Jacobson: Well, we've been developing plans for all 50 states in fact, and now 139 countries and California in particular, and these plans are to convert each state to 100% renewable energy not only for electricity but also transportation, heating, cooling, industry, agriculture, forestry and

fishing. And the idea is to electrify everything. If you electrify everything the first thing that happens is you reduce power demands. In California, that's about 44% reduction of power demand and that's because if electricity is much more efficient than combustion. So for example, an electric car, 80% to 86% of the electricity goes to move the car and the rest is waste heat. In a gasoline car only 17% to 20% of the energy in gasoline goes to move the car and the rest is waste heat.

But you not only reduce the power demand by converting to electricity due to the efficiency of electricity but also because you no longer have to mine and refine and transport fossil fuels, there is an energy reduction there as well and there's energy efficiency improvements. In California that's 44% reduction of power demand by electrifying. And then you provide all that electricity with clean renewable wind, water and solar, onshore and offshore wind, solar rooftop PV and power plant PV, photovoltaic that is, concentrated solar power with storage, some geothermal power, existing hydroelectric power in small amounts of tittle and wave. And we found that you can do this in California, use less than half a percent of the state's land area for what we call footprint on the ground for mostly for solar at the utility scale and about 1-1/2% of the land area for wind, onshore wind and we can power the entire state and then we have offshore wind too but in terms of land area not using much land we can power the entire state similar or lower direct cost but we reduce the social cost or the health and climate cost by about 60% for Californians and create jobs in the process and create energy stability forever.

Greg Dalton: Steve Malnight, you're in the electrical business, electrify everything, you probably agree with that, but how about the other part of that, it can be done at 100%, it is doable and fairly soon.

Steve Malnight: Well, I think it definitely meets the definition of a big hairy audacious goal, a BHAG for all of us. You know, it is the right kind of thing for us to be talking about to set out those aggressive goals. You know, at PG&E we've been extremely focused on the challenge of how we in California lead on climate, how we lead the way. I think we've been very supportive of that and when you look at the electric sector today you're already seeing a transformation happening in the electric sector today with the 30% renewables that we deliver, 50% GHG free that's only increasing over time. It's getting cleaner and cleaner. That can be done and we're demonstrating that here today.

So, you know, I think from the perspective of can we do it, you know, I have confidence that over time we can accomplish a lot of these kinds of things and these are the right kinds of discussions for us to have. The question at the end of the day is, how do we make sure we're achieving the climate goal that we really have straight and center in front of us and, you know, I think Mark here, your point is we can't just look at the electric sector today. In California that's really only about 20% of the emissions. 80% of the carbon emissions in the state are from all the other sectors outside of the electric sector. We've got to make sure we address transportation; we've got to make sure we can address the industrial uses and those really are the biggest challenges we have in front of us today. So, you know, I think we've proven in California we can accomplish some amazing things and technology can come along and help support it. So, you know, I'm all for giving it a go. We'll have to see how we get there and what the best choices are for California and for our society to make sure we keep making the progress we need to.

Greg Dalton: So it sounds like you two agree on direction; is the difference over pace, when? Mark Jacobson, when do you think that 100% can happen in California?

Mark Jacobson: Well, our goal is to get 80% by 2030, and 100% by 2050. Governor Brown said 50% in electricity sector by 2030, so it is about 60% of our goal.

Greg Dalton: So 35. Steve Malnight, is that realistic? 100% by 2050?

Steve Malnight: So we're really focused on making sure we can achieve the 50% goals the governors laid out and which is already incredibly ambitious, but beyond that we're focused and we've already committed to go beyond it, to go to 55% renewables with the transition away from Diablo Canyon and to continue that march forward. Whether it's feasible by the time, I'm not exactly sure. It's been a big challenge to get here, but the point is we've got to keep making the progress.

Greg Dalton: Mark Ferron, the utilities always say, oh it's gonna be hard, it's gonna take longer, but they oftentimes get to those goals faster than people anticipated five years ago. So what do you think about 100% by 2050?

Mark Ferron: Well, I think I agree with Mark that that's the kind of goal that we should be setting out. But it is a complicated exercise so I think we have, like Steve, we have focused very much on the near-term goal which is the 20%, 30%, 50% renewable portfolio standard and I'm very confident that we're going to meet that. In fact, I expect that we should beat that whether it's 55% or 60% is not clear. But I think that's really, we have to put it into context; that is essential if we're going to get to what we need to do in terms of reducing greenhouse gas emissions. So 50% renewable is just barely on the edge of being consistent with a 40% reduction in greenhouse gases by 2030 from the 1990 levels, which is what scientists tell us we need to do to keep the impact of climate change at a manageable level.

Now, going beyond that gets much more difficult and it's because we are very reliant on fossil fuels in California in particular natural gas for making up for the intermittency and the variability of renewables. And that is a tricky engineering exercise to get around. So if you think about it, if you do the math, 50% renewable energy plus hydro, et cetera, you get to somewhere around 25% natural gas which is very low. And going below that really does raise some questions about reliability of the system.

Greg Dalton: Mark Jacobson, the sun doesn't shine at night, the wind doesn't really blow in the day, the renewable power is not always there. We need to run the economy of the state, we need electricity always there. What's your solution to that?

Mark Jacobson: Yeah well, we've solved that problem in theory because when you electrify all sectors, suddenly everything is electricity including heating, cooling, industry, and so you can now use heat storage which is low-cost and cold storage to reduce electricity use. For example, Stanford University, the University I work at, they've had an ice cube under a building since 1998. So at night when electricity prices are low, they use the electricity to create ice so that during the day instead of using electricity during peak times of the day in the afternoon, they run water through tubes in the ice and cool with water that was used to cool buildings so they reduce peak time electricity demand.

It's really ideas like this where you combine heat and cold and with electricity's low-cost electricity storage in pumped hydroelectric power, existing hydroelectric power, it's a big battery, concentrated solar power is 1/10th the cost of batteries. And then in using other types of heat storage such as in rocks which is only a dollar a kilowatt hour compared to \$300 a kilowatt hour for batteries, you can actually solve the problem. We showed this over the whole of United States. We did a paper that was published last year in the proceedings of the National Academy of Sciences where we examined is it possible with 100% power for all sectors in clean renewables in the whole US, is it possible to keep the grid stable. We found that it was at a cost similar to the cost of fossil fuels.

Greg Dalton: Steve Malnight, there's a difference between academic theory and practice in industry, so do you think that some of those theories that are practical now in the industry can scale up?

Steve Malnight: I mean, as Mark said, I think that there already are a lot of innovative technologies that are being used by customers every day. Thermal storage is something that is out there, it's available, as Mark said it's been used and being used every day today. You know, I think that from my perspective one of the things that Mark said is really important. It's going to take all options to come onto the table and we do have to translate theory to practice. We have to be able to prove them out in actual practice on the grid and, you know, that really needs to be our focus is making sure that these new technologies that show the promise that we move them out of the theory through the lab and into commercial scale and into practice, then we'll know how they all work.

Greg Dalton: Mark Ferron, Diablo Canyon is the last remaining nuclear power plant in the state. It is about 9% of the state's electricity. It's going to be shut down in seven or eight years. There is quite a debate about whether nuclear should be part of the future of America, a carbon free energy that's already decided, but the question is can renewables really fill that void reliably, what do you think right now?

Mark Ferron: Well, I think that the case of Diablo Canyon is very different than the case of San Onofre in Southern California. San Onofre went out kind of without any warning. Okay. There was a minor radiation leak and it was decided that the plant needed to be shut down. And that did lead to an increase in emissions in the immediate term in Southern California. Totally different situation with Diablo Canyon. Because of careful planning by PG&E and others, I think we're all feeling pretty confident that we can replace the power, we can replace it on a carbon neutral basis and that is the right thing to do.

Greg Dalton: Other parts of the country, there are nuclear power plants. A lot of the licenses are being extended, plants are already built, they are producing carbon-free electricity today. Do you think those plants ought to continue nationwide, that the ones that are already running should continue producing carbon-free electricity?

Mark Ferron: Well, I think it has to be looked at on a case-by-case basis. I think there may well be cases where extending nuclear licensing makes economic sense. Where there's not significant problems as there were in the case of Diablo Canyon with the once through cooling rules about taking in seawater and returning it at the right temperature. But I think it is an economic issue and what we found now is that renewable energy has fallen so dramatically in price that it is difficult for even an existing depreciated plant if it requires refurbishment to compete in these markets.

And I think that's why you're starting to see in many parts of the country as nuclear plants come off their long-term contract and they're required to compete directly with wind and solar and other resources they're just simply not cost-effective.

Greg Dalton: Steve Malnight, what would it have cost to keep Diablo Canyon running? How much is PG&E saving by shutting that thing down?

Steve Malnight: Well, I mean, when you look at it, there's a lot of factors involved in that and as a company, you know, I think it's fair to say we're supportive of nuclear technology and we believe Diablo Canyon is an incredibly valuable resource for California. It's generated power consistently, reliably and safely and clean over its entire operation. Which is why when we looked at the best path forward we recognized in California it might not make the most sense given the policies and choices that we've made in California. That doesn't necessarily mean it doesn't make sense in other jurisdictions where they have different resources and they've made different policy choices. But for us, we recognize in California once through cooling as Mark mentioned is a priority for the state to mitigate those impacts that was going to be expensive to retrofit Diablo Canyon or to deal with mitigation costs associated with it. Obviously, maintaining and reinvesting in the plant to run it for

another 20 years would cost money.

But I think the biggest issue that challenges Diablo in California from a cost perspective, is the fact that, you know, nuclear power generates 24 hours a day, seven days a week consistently and when we have a portfolio in the electric system today that involves a tremendous amount of clean but more intermittent resources that base load profile is just not the kind of resource mix that we really need for the future. We need more flexible resources that can ramp up and down. And what we would see is that Diablo just would not be needed as much. We would not need as much of the generation out of Diablo which would significantly impact the costs. So, you know, we looked at all of that together and said Diablo doesn't make the most sense for California, nuclear power may make the most sense in many other jurisdictions where they don't have the same resources, but for here that was the right choice.

Greg Dalton: Mark Jacobson, in your group I have to take it is pretty opposed universally to nuclear.

Mark Jacobson: Well, we look at it from a scientific point of view. We're not advocates one way or the other. But from a science point of view, well, we have to distinguish between new nuclear and existing nuclear and then existing nuclear we want to look at a case-by-case basis. When you're talking about new nuclear power we have to consider the entire lifecycle emissions which are about 6 to 24 times higher in terms of carbon dioxide equivalent emissions and pollution than wind energy, for example. And half of that is due to the fact that you have to mine and refine uranium through the entire life of the nuclear reactor and that takes energy off the regular electric power grid which is still primarily coal and gas.

And then the other half is the fact that it takes so long to put up a new nuclear power plant. It takes between 10 and 19 years between planning and operation compared to 2 to 5 years for a wind or solar farm that while you're waiting around if you had a certain amount of money and you spend it on a nuclear plant instead of a wind or solar farm, you're spending basically an extra, you know, 8 to 14 or 15 years waiting around running a regulator electric power grid and so those emissions have to be accounted for.

And that's not -- those aren't the only issues, you have nuclear weapons proliferation issues with new nuclear power plants going into countries that don't have them. You have waste issues, you have meltdown issues of 1.5% of all nuclear reactors ever built to date have melted down to some degree. And then you have cost. Right now it's four times more expensive for new nuclear plant compared to a wind farm and so you're basically getting one-fourth the energy for the same amount of money whether it's intermittent or not. And so, it doesn't make sense for any new nuclear to go up. With regard to existing nuclear it's a case as Mark Ferron says it's a case-by-case basis. It really depends like in New York, the governor decided to allow three upstate nuclear plants to persist, but they were going to pay a subsidy of \$7.6 billion to keep them going.

But if it turns out if you actually took that same money and you have to replace them anyway by 2028 so you'll need to spend money on wind and solar at that point anyway, so if you took that \$7.6 billion you'd get 60% lower carbon emissions if you use that to buy wind and solar today instead of just giving to this company, Exelon, it turned out. So there was no advantage of keeping those open from a carbon point of view or a cost point of view.

Greg Dalton: We're talking about the future of California energy at Climate One. I'm Greg Dalton. My guests are Mark Ferron from the California Independent System Operator, you just heard Mark Jacobson from Stanford University and Steve Malnight is with PG&E.

In 2014, we had David Crane here, CEO of NRG Energy. He came to Climate One and told us about a letter that he had written to shareholders that was quite emotional and different than most CEO letters at energy companies. He laid out a plan for NRG to get to zero carbon emissions for its electricity. Let's hear what David Crane had to say a couple of years ago.

[Video Playback]

David Crane: I was really trying to motivate the 10,500 people that work at NRG is that, yeah, you know, we're trying to make money and all that but we're basically trying to, you know, save the world whether you're a public corporation for profit, a not-for-profit, a member -- you know, a thought leader in society, the time is now. You know, the science is beyond dispute. The excuse that we don't have the technology is just not true anymore. We have the technology.

Greg Dalton: Later on, David Crane went on to say that he talked about the risks of kind of sticking his neck out there taking a moral stand in a financial instrument and he said the worst thing that could happen to me is they could fire me and if they fire me, they'd have to pay me even more money to go away.

[Laughter]

Well, that's exactly what happened to David Crane. He got fired and he got some money, paid some money to go away.

But so, Steve Malnight it raises the question of how far a leader can get out in front of their shareholders in this industry and how do you think about pushing the edge and thinking about shareholders want you to deliver that steady coupon clipping return that retirees typically relied on for utilities.

Steve Malnight: Well, you know, I mean, I remember when I read David Crane's letter. The first thought that went through my head is, welcome to the club. Because I think in California, you know, the utilities have been seeing the same message consistently really since early 2000s when we supported AB 32 with the fact that, you know, the science is clear, we need to address climate change, the electric sector has a role to play, let's get on with it. So I think that the important thing and I'm not gonna address, you know, David Crane's specific issue at NRG, there's lots of --

Greg Dalton: But how about pushing the industry forward.

Steve Malnight: But from the -- you know, I think from the -- you look at where California is at, utilities are inherently companies that do well when our communities do well. When the state of California does well, PG&E will do well. And I think in California we've clearly set out the leadership goal on climate. We are a full partner in that and we continue to move forward. That's actually good for the company. It's good for PG&E. It's good for our shareholders. It's good for our customers and good for the state. So I believe you can go a long way in leading on that front when you draw the clear case for change; why that's a benefit to an investor in PG&E, to a customer at PG&E and to the communities we live in.

Greg Dalton: Mark Jacobson, there's lots of new entrants into the electrical market, there's more competition for PG&E. How is that going to help get to 100? Is that gonna slow things down? Or cities like San Diego, Marin, San Francisco now getting into the market is that gonna slow or accelerate change move toward 100?

Mark Jacobson: I'm not really sure I can answer that. I mean we set sights on the end goal of 100% renewable energy and have kind of an interim target.

But we actually think each state and each county, each state in each country has to figure out the best way to get there. And so, you know, we think if people believe in the end goal and people are committed to doing it, they'll find some way, they will work through all the issues. So I can't really say specifically if one's strategy is gonna work faster, better than another.

Greg Dalton: Mark Ferron, you're part of the organization that runs the grid that has to manage all these electrons moving every which way every day, really complicated job. How do you see new entrants and new competition, there's a lot more consumer choice now. We didn't use to have a choice, now in San Francisco, you have a choice. In Marin, you have a choice. Customer choice is coming to this market. Is that going to drive it to a cleaner market?

Mark Ferron: Well, as a former regulator, I think looking at more consumer choice is a headache because it makes it more complicated. It is much simpler to regulate a market that comprises three regional monopolies and that's the state of play now in California but being eroded by community choice which is coming across the state. Now personally, I believe that consumer choice can only be a good thing. And what we are seeing increasingly in communities that are looking that this as an option is they want cleaner energy than what's available on the grid. And so, I'm a customer of Marin clean energy and I run my electric car in 100% clean energy and that's a choice I make. I pay an extra penny a kilowatt hour to do that. I love having that option. And it's interesting as you look at what's emerging across the state, there's some really very interesting innovative work going on at the local community level. And one of the things that we're trying to do at the California Independent System Operator is tap into that and allow third parties who have various renewable assets on the grid to aggregate those assets together and bid them into the wholesale market. So we are actively encouraging another route for renewable resources to get on to the grid.

Greg Dalton: Steve Malnight, PG&E has tried to stifle this competition. Do you now accept that that this is happening and that the consumers will have more choice and you're competing in the marketplace where you used to have sort of your customers locked up?

Steve Malnight: Well, I'm not sure I'm going to accept the premise of that question but I will say this, I think, you know, from our perspective, we support our communities when they make choices to go to community choice aggregators. And one of the things I think is important, Mark, I appreciate that you're a customer of Marin clean energy; you're a PG&E customer as well. Because PG&E's core business is really about delivering those electrons to your house and making sure they're available and reliable whenever you need them, whenever they're there.

I think that engaging customer choice in the marketplace, whether it's through community choice aggregators or through customers who make choices to put solar on their roof tops like I did, those are all good things for this marketplace in the long run. Because frankly, for us to solve the problems we have from a climate perspective in the energy business we need customers who care about their energy and are engaged and are making choices and are actively managing their energy use every day. When customers think it's not a big deal, it doesn't matter; we're set back in our accomplishment of our goals. So we, I do not fear competition in any way here. Frankly, it's not exactly competition; PG&E doesn't make our profit from buying and selling electrons. As a company we make our profit by investing in the grid that delivers it to Mark every day.

Greg Dalton: We're talking about clean energy at Climate One. That's Steve Malnight from PG&E. We also have Mark Ferron from the California Independent System Operator and Mark Jacobson from Stanford University.

We're going to go to our lightning round. We ask each person a yes or no question starting with Steve Malnight. Yes or no, rich people in California breathe cleaner air than poor people?

Steve Malnight: I mean, I think that there are issues; there are issues we have to address in economically disadvantaged communities in the state.

Greg Dalton: Yes.

[Laughter]

Steve Malnight: I'm sorry I'm not good at one-word answers.

Greg Dalton: Mark Ferron, when Mike Peevey was president of the California Public Utilities Commission the commission got too cozy with the electrical utilities they regulated, yes or no?

Mark Ferron: Yes.

Greg Dalton: Attorney General Kamala Harris is investigating possible criminal charges against Mike Peevey for private contact with the company he used to run. Steve Malnight, PG&E CEO Tony Earley was brought in to clean up the mess created by his predecessor, Peter Darbee, whose reign included the deadly San Bruno blast for which the company was recently convicted of six federal felonies.

Steve Malnight: Tony was brought in to solve a lot of those issues, so yes.

Greg Dalton: The cleanup job is close to being finished at PG&E. And PG&E will then hand over the reins to the current president Geisha Williams.

Steve Malnight: They don't ask me.

[Laughter]

Greg Dalton: Mark Jacobson, oil industry executive Jay Precourt gave \$30 million to Stanford to fund the university's umbrella institute for energy studies. Exxon Mobil gave Stanford \$100 million. The University's reliance on funding from fossil fuel interests, compromises its research in the climate and clean energy?

Mark Jacobson: In part, yes.

Greg Dalton: Steve Malnight, in 2010 PG&E spent \$40 million on a statewide ballot initiative that would have made it harder for communities to start supplying power and competition with electric monopolies, Prop 16. That alienated many PG&E supporters and was a mistake.

Steve Malnight: Yes.

Greg Dalton: Steve Malnight, you mentioned earlier that PG&E supported AB 32, California's landmark climate law. So question now for Steve Malnight, PG&E supports the extension of that landmark climate law known as AB 32.

Steve Malnight: Are you talking about SB-32?

Greg Dalton: Do you support SB-32?

Steve Malnight: As it was written we thought there was more than needed actually be done to extend cap and trade. But we clearly support the governor's goal of 40% and felt that legislation needed to be passed to enable it.

Greg Dalton: Okay. Mark Ferron, electric utilities are being more cooperative in the transition to a cleaner economy than oil companies and refineries?

Mark Ferron: Absolutely, yes.

Greg Dalton: Mark Jacobson, PG&E is one of the cleanest electric utilities in the country?

[Laughter]

Mark Jacobson: One of, yeah.

[Laughter]

Steve Malnight: I know it's hard. It's okay.

Greg Dalton: Begrudging praise. Mark Jacobson, electric utilities are dinosaurs dying a slow death?

Mark Jacobson: Yes, yes, I think so.

Greg Dalton: That was a yes?

Steve Malnight: Can I answer that?

[Laughter]

Greg Dalton: Mark Ferron, professors who have never put concrete and metal in the ground overestimate how difficult it is to build energy system? It's a lot harder than computer models suggest?

Mark Ferron: Yes.

[Laughter]

Greg Dalton: Mark Jacobson, Japan is 10 years ahead of the U.S. on using electric cars as storage for the grid?

Mark Jacobson: No.

Greg Dalton: Mark Jacobson, electric utility monopolies are the number one obstacle slowing down the United States and the transition to carbon free power?

Mark Jacobson: No, not the number one.

[Laughter]

Greg Dalton: Steve Malnight, nuclear power is renewable power?

Steve Malnight: No.

Greg Dalton: Steve Malnight, opponents of nuclear power are ideological and not grounded in science?

Steve Malnight: I think we all have disagreement -- maybe there's disagreements, there's reasoned disagreements on that point.

Greg Dalton: Last question, Mark Ferron, a 100-percent clean power plays well in Hollywood, but isn't grounded in reality?

Mark Ferron: I don't think that's true. I think we can get to 100-percent renewable.

Greg Dalton: Alright, how'd we do? I think that's the end of our lighting round. They did pretty well.

[Applause]

[CLIMATE ONE MINUTE]

Announcer: And now, here's a Climate One Minute.

In California and a handful of other states, some households can now choose to get their power from local electric companies, also known as community choice aggregators. These offer a portfolio of renewable power options; some claim to have reduced greenhouse gas emissions dramatically. Sounds good -- but Matthew Freedman of the Utility Reform Network says it's still important to ask the right questions.

Matthew Freedman: *I think what customers really want to know is does their choice end up being meaningful? Does the decision to switch providers result in a change in the way the power is produced on the grid. Are there actually less carbon emissions, is anything different because you made this choice. I think there, the jury is out.*

There's a lot of talk about reducing carbon emissions or percentage of the portfolio coming from renewable resources but so far, the vast majority of the transactions that have been done on behalf of customers of community choice aggregators have been short term transactions from existing facilities that haven't actually changed any of the output on the system. So, the long term question for community choice aggregators is, does the grid look different because they're there or is this just an exercise in folks taking credit for stuff that's already happening? And that's the open question.

Announcer: That's Matthew Freedman of the Utility Reform Network, a consumer advocacy group. He joined us in 2015. Now, back to Greg Dalton and his guests at The Commonwealth Club.

[END CLIMATE ONE MINUTE]

Greg Dalton: Talking about clean energy in California at Climate One. We did a poll on Twitter today. Do you think California already has the technology needed to get to 100-percent clean power? 250 votes split 50/50. Half the people think we need more technology. Half the people think we have all we need. Steve Malnight, which is it? Do we have everything we need, we got to deploy it, or we have to create new innovation?

Steve Malnight: No, I think we need new innovation. I think, you know, even as Mark alluded to. I think there's a lot of things that sit in the theory today that are very promising, but I think we've got to prove them out and understand the complexity of integrating these things on to the grid and how you run the system to make sure we maintain the reliability that we need.

Greg Dalton: Mark Jacobson, where does the new innovation need to happen? Where are the big breakthroughs that you see that need to happen to get to a 100%?

Mark Jacobson: Well, let me preface it. I think with existing technology if you deploy it, you'll get new innovation along the way. Because deployment drops the cost there's more money available for research and so you can then, but we do not need a miracle new technology. So it's maybe fine-tuning existing technologies using them on larger scale especially the storage technologies that are really used in lot of example places, but we've never had a need for these large-scale clean renewable energy storage before. So I think the biggest barriers if you're asking that are really practical things like zoning for long-distance transmission getting offshore wind, floating offshore wind turbines.

And once you have floating offshore wind turbines commercialized, then the game is over because there's just endless amounts of offshore wind on the West Coast, East Coast U.S. around the world. So I think it's really deployment that will generate more improvements of technologies, plus some better policies that we'll put in place and speed up certain things like floating turbines and long-distance high voltage direct current transmission.

Greg Dalton: Mark Ferron, you've worked in Silicon Valley in innovation. You worked in Sacramento in regulation. What's the role of government and private companies in driving this innovation that we're talking about?

Mark Ferron: Well, I think the role of government is to set the rules, make them as clear as possible and then try to get out of the way and let the innovation happen. I think that's really the fastest way for this to come about. And just to dovetail what Mark was just saying, I think there is there's really not a need for some giant miracle breakthrough in the hardware space. I think the hard technology that we have around electricity generation, of course there are improvements that are happening all the time. Wind turbines are getting more and more efficient, et cetera. But the basics of that I think are largely well understood. It's the soft stuff. It's the software piece of this. It's how it knits together, how it's integrated, how it's managed. I think that's the biggest obstacle. And I think that's where the biggest dividend will come in. And I mean the good news in all that is that is the in a sense, the specialty of Silicon Valley. And so on those grounds I'm quite optimistic that as we lay the foundation from a policy standpoint and we get more hardware in the ground as it were. And people begin to work on ways to optimize that to make it more efficient, to make it more resilient I think we're gonna see some real dividends.

Greg Dalton: Steve Malnight, the smart grid. We talk about the grid. Let's talk about that some more in terms of what it is or what needs to be done to make the grid smarter. That term is thrown a lot of, around a lot not sure people really know what it means. Is the grid ready today for 100% or for more renewables?

Steve Malnight: I mean I don't think it's ready today for that level. I think there is a significant amount of investment that we need to do to change the way the grid operates. And we do have to remember the grid was built as a machine that transmitted power from, in a one large central station generating facility through high-voltage substation brings it to lower voltage takes it to your home. It was not an envisioned world at that time that two-way power flows were gonna happen. It wasn't that long ago, and frankly there are utilities in this country that don't know you're out of power until you call them and tell them you are. That's not the case at PG&E but it is the case in other parts utility and it's not that far in our recent past.

So when we talk about the smart grid what do we mean? It's fundamentally about turning that machine into a machine that you can monitor all along the system to understand the current

operating conditions of the system. To understand what's happening to understand what's happening on the customer side and on the generating side. It's about control. So it's about allowing the grid to use technology and innovation and automation to self-heal, to move power and route power on its own, to quickly respond to the conditions that we're monitoring. And it's really also about creating an information architecture and structure so that when a customer puts technology on their home, they can actually integrate it effectively, so that we can do the things like Mark talked about earlier, where if a customer has a power wall in their home or a solar system in their home, they can actually extract more value for that by delivering benefits to the overall grid in the system. That requires information communication and technology.

Greg Dalton: Mark Ferron, some Silicon Valley companies, Google tried to partner with utilities to, they had something, Microsoft tried to partner with utilities on sharing data, didn't work out so well. The rap from Silicon Valley companies is that utilities are slow, not very smart and agile companies because they were regulated to be consistent. They have not been created to be innovative. They were regulated to be reliable, steady producers of electricity and cash flow for their investors. So the question is how can innovation come to these big, lumbering giants and how's that going to happen?

Mark Ferron: Well I mean I think utilities and it's not just the distribution utilities. It's also true to some extent of the transmission operators such as the ISO. We are by nature conservative animals, right. And we are dealing with an essential supply of a service which, you know, we all here in California know firsthand what happens if you, you know, mess up the system. And that can lead to billions of dollars of costs and millions of customers being out of power and so on. So I think there's a real reason for being very conservative. But that said, I think there are things around, I mean innovation is happening kind of whether the utilities like it or not. There are third parties out there who are coming up with new approaches to how consumers interact with their energy. We have the largest manufacturing plant in the state of California makes electric cars, didn't exist, five, six years ago. And I think that is increasingly going to be a gateway drug for innovation across the sector.

Greg Dalton: We have lots of users in the audience, I can tell, yes.

Mark Ferron: So I don't, you know, it's undoubtedly the case that the utility sales cycle is very long and very slow. And I do think that we need to think about ways to speed that up. When I was at the Public Utilities Commission, I was a big fan of having pilot programs. So get the utilities to test something out and see how it works. But we need to move beyond pilots; we need to move into actually proving these things out at scale. I think that is going to be really the challenge for the next few years. How do we do interesting innovation at a significant scale? And I think that's what we're going to see.

Greg Dalton: Steve Malnight, there's about 100,000 plug-in cars in California, that's growing. What's the role, how important are EV's to this electric future, to this clean energy push that the state is pushing?

Steve Malnight: Well, I mean, you know, electric vehicles and the way that we go about cleaning up the transportation sector is vital for the state to achieve their objectives. We can't get there without cleaning up the transportation sector. So it's incredibly important. I think that there is also a great opportunity to do it because, you know, as Mark was alluding to before we have an electric system that is already incredibly clean and is getting cleaner. And as I remind everyone, you know, your plug is far more ubiquitous than a gas station. So the transportation fueling infrastructure is really already well-built out with the electric system to drive us to electrified transportation and that's going to help us really make the significant change we need to achieve the climate goals in the state.

Greg Dalton: If you're just joining us, Steve Malnight is the Senior Vice President of PG&E. Other

guests today at Climate One are Mark Ferron from the California Independent System Operator the agency that runs the state electric grid and Mark Jacobson from Stanford University. I'm Greg Dalton.

Greg Dalton: So let's go to our questions at Climate One.

Male Participant: Hi, this is for Mark Jacobson. Are we on track in California to match your goal for 80% and 100% time wise, and around the world who's doing well and who isn't?

Mark Jacobson: Well, surprisingly California if you just look at the wind, water and solar which is our plan is 25% in the electric power sector. So we're actually doing pretty well in the electric power sector. Governor Brown's goal is 50%; our goal is 80% by 2030. You know, it's pretty well but I think we can get beyond 50% by 2030. The other sectors though are lagging pretty far behind, so not so well. Worldwide, Norway is the furthest along in terms of installation of everything to get 100-percent renewable energy. They have about 55% of everything they need. The United States in comparison has 3.7% of everything they need. China has like 3.1% or 3.2%, so there are some countries that are smaller that is doing much better.

Greg Dalton: Small oil-rich country leading the way. Let's go to our next question.

Female Participant: Hi, this is Jessica Lamb from Climate Works Foundation. Given that grid energy mix policy incentives and utility business models will look different under a near term 50% renewable energy scenario versus 100%, could you speak to what is being done or could be done to ensure compatibility between those two scenarios so that we ensure what we're doing now and then near and midterm will be compatible or sort of a glide path for that future 100% renewable energy goal?

Mark Ferron: I'll take that.

Greg Dalton: Mark Ferron.

Mark Ferron: Yeah, I have to say that's one of my biggest concerns about, you know, our because we are investing a huge amount in the grid. In the last 10 years the rate base for the utilities in the state of California have doubled and projections are they will double again in the next 10 year. So this is a massive investment in hardware and it's really essential that we look hard to make sure that we are not digging a deeper hole. That we're not, you know, we're not gilding the existing infrastructure and that we're actually building the sort of things that we're going to need for the grid of the future. So that is I think a genuine concern. Now, how do we go about that, I think it's really comes down to the regulators looking carefully at incentives that the utilities have. Creating an incentive for the utilities not just to put steel in the ground to invest in hardware and get a return on that, but also to invest in services that can be provided by third parties and getting a return on those services as well.

And I think this is an area where quite frankly, California is just beginning the state of New York has really grabbed onto this in a very impressive way in laying out their vision of how regulation is going to work in the 21st century. I think there are many things that California can learn from the state of New York.

Greg Dalton: Next question in Climate One. Welcome.

Male Participant: Thank you. Gary Loche [ph] from Cupertino. I'm gonna ask about different aspect of this: military security, Ted Koppel has written a book called Lights Out in which he documents pretty convincingly the susceptibility of our system, both from a cyber-attack or even

small rifle attacks. Could each three of you give me how converting to renewables will either help or hinder this issue of military security.

Greg Dalton: Steve Malnight, FBI works with utilities on this thing.

Steve Malnight: Yeah, absolutely it's one of the primary risk that we look to in our sector in our industry. We work very closely together as an industry, we work with the federal government. We work with the organizations like the independent system operator across the country. I will say that, you know, to some degree it's an issue we have to deal with no matter how we generate electricity. And it's one that we have to look to, to share best practices and learn and continue to grow as an industry. I mean candidly in the space, you know, we are often challenged with nation states looking to exploit vulnerabilities in our system. And we've got to work together with the government and others to make sure we harden that system and secure it.

Greg Dalton: There's an argument that distributed grid with more points of generation is harder to defend than a few big assets that can be kind of hardened and --

Mark Ferron: I would have to turn around and say it's easier to defend. Okay, there are more points of entry. But there's also the ability then to island and so you don't have critical pieces of infrastructure that cause a cascading effect so --

Greg Dalton: Harder to take the whole thing down.

Mark Ferron: Harder to take the whole thing down. There are more points of entry of course and that's the risk. But on the other hand, inherently the structure is more robust.

Greg Dalton: Which is the whole point of the way the Internet was constructed anyway, that's the whole architecture of the Internet. Mark Jacobson.

Mark Jacobson: I was just going to say there's, the push for putting battery systems with solar togetherness is in fact Tesla is no longer Tesla Motors, it's Tesla because they've combined with Solar City and they're going to produce a single product where in fact the battery, you know, the solar will be on your roof and you'll have batteries together. So when you actually have more systems where people can almost be self-reliant to some degree, then that can reduce risk as well.

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

Female Participant: Thank you. Hi, my name is Wendy Jones. First, I want to say thank you for our collaboration amongst all of your organizations, we're going to continue to need it, so please keep it up. My question I guess is for Mark. You mentioned how renewables can address the issue of mining and extraction of fossil fuels. And I recently read a paper that you and a colleague had written about a similar issue related to renewables with rare earth minerals and elements and plutonium and lithium and who owns it in the world and how we're going to keep doing it. And it seemed to me that your answer was related to kind of banking on recycling technologies of these mining things that we need. And so I would like you to address that like how much, are we solving one problem only to create another?

Greg Dalton: Mark Jacobson, I hear a lot. What about those batteries in electric cars? People are really concerned about that.

Mark Jacobson: Well, I should first point out that the mining from fossil fuels is continuous forever. You have to keep mining natural gas. In fact, every year there are 20,000 new gas wells that are built and you have to do, in the U.S. there are 3.6 million of them just marking the United States. So

versus one time when you're building a windfarm or solar panels you do that one time mining versus forever continuously. But having said that, you do need some and for batteries you do need lithium, you do need neodymium for some permanent magnets and turbine generators but not all. But these can be recycled; there are plenty of resources you don't need to remind these forever as much them, the orders of magnitude less mining. You have to it but it's much, much less, much less impact on the environment.

Greg Dalton: Talking about clean energy at Climate One. Let's have our next question.

Male Participant: My question is to Steve and former Commissioner Ferron. Until there's a change in the profit structure or how PG&E and the other utilities get paid much like the change in decoupling 35 years ago that enabled the boom in electric energy efficiency and the success there. I think we need to change or think about or start talking about changing how do we help PG&E get off of its profit reliance on its gas infrastructure. Until we solve that problem we can't get PG&E and the other gas utilities full-throated support.

Greg Dalton: Mark Ferron, helping PG&E get off their hooked on gas profits.

Mark Ferron: Well, I agree with Steve that we're gonna need gas for the next period of time 15, 20, 35 years. I hope it's lower. I hope it's less. I have to say that the leak in Aliso Canyon, which happened at the end of last year where 5.4 billion cubic feet of natural gas escaped in four months. That was a real eye-opener and it made us I think all realize how dependent we are on natural gas for electricity sector and how damaging leakages can be to the environment. So I think this is really a key priority and I think this notion of electrifying everything is really absolutely the right thing. We need to be thinking about how do we get off fossil fuels as opposed to how do we transition around them. You asked the question earlier about oil companies. They're in the crosshairs and they have pushed back very hard. I hope we don't get the same response from the natural gas industry because that is the way the future is gonna look whether it's in 15, 35, 50 years.

Greg Dalton: Let's go to our next question.

Female Participant: Thank you. Abby Young with the Bay Area Air Quality Management District. In the San Francisco Bay Area we have over 65 local government cities and counties that have adopted local climate action plans and that's more than any other metropolitan area in the country. What is the role of local and regional government in the Bay Area to help speed us along this pathway toward 100-percent clean energy?

Greg Dalton: Mark Jacobson.

Mark Jacobson: I'll take that. So, I mean there are already efforts by cities not only in the Bay Area like Palo Alto is an example but around the country that have goals to get to 100-percent renewable energy. So there can't, a city can actually have such a goal and even pass ordinances in fact Palo Alto is thinking of passing an ordinance -- thinking about, haven't done this yet -- where they actually, all new construction cannot have gas go on the property because you don't need it anymore. So this is something the city can do if they really want to go to 100% they can look in fact we're working with the city to develop ways to look at all the pollution, all from every sector and how to get rid of that. And actually for most things you can do it, there are existing appliances for everything in your home there's nobody needs gas in their home. You have induction cooktop stoves, heat pumps for air and water heating, electric dryers. What you need gas for, you don't need it to go in your house. And so you can do this throughout the city. And what you do about for example cars from outside the city coming in that are gasoline powered cars, how do you inhibit those? Well you don't create parking spots for them.

[Laughter]

Greg Dalton: Let's go to our next audience question at Climate One.

Male Participant: Hi, Phil Keys with Intertrust Technologies. Question about the grid, I'd like to understand how you see how far we can get with the current grid by, you know, just putting on this layer of communications and computation towards the goal of 100-percent renewable. And once we reach that point, what changes to the grid need to be made?

Mark Jacobson: Well, I mean if you look at it on a large scale like the whole U.S. you definitely do need upgrades and transmission particularly long-distance transmission. For example, you know, the best wind resources in the U.S. are offshore the coasts, but also in the Great Plains which is like the Saudi Arabia of wind. And so you can actually, it's so cheap there two cents a kilowatt hour with the production tax credit now and three and half without it, that it's actually cheaper to transmit that energy to the east coast right now than even offshore wind.

So upgrading long-distance transmission is certainly something that would be beneficial, but so I don't think you should wait till the end to upgrade long-distance transmission. I think that should happen now. I should point out there that in Texas there is an example I just read. In Texas just like four years ago, 16% of all the wind energy was basically not used, it was curtailed because it didn't have enough transmission. And this last year of 2015 that dropped to 1%. So instead of wasting 16% of the electricity only 1% is now because they upgraded the transmission system in just a few years.

Greg Dalton: Mark Jacobson is a professor at Stanford University. Other guests today at Climate One are Mark Ferron, state regular operator of the electric grid and Steve Malnight from PG&E. I'm Greg Dalton. Let's go to our next question.

Female Participant: Hi, I'm Candace Hyde Wang [ph] and I'm with the League of Women Voters in Berkeley, Albany and Emeryville. And we're concentrating; my concentration is on building energy upgrade which you spoke to a little bit about. But we have so many homes in California that would have inadequate electrical services, inadequate wiring, very expensive to upgrade homes, rental units. It will take probably billions of dollars. How will we get that money? Some people can afford it, but many people will not.

Greg Dalton: Steve Malnight, lot of efficiency gains in California yet the best thing you can do before solar is seal your home and make it more efficient. But that's not as sexy and that some people don't know how to do it or how to pay for it.

Steve Malnight: Well, it still is vitally important. And I do think we have to, to your point there's a lot of infrastructure that needs to be invested in not just the grid itself, but also in our homes as we talked about the gas transition earlier as well. We have to look for every available way to get that to happen. We do that through policy, we do that through incentive structures, we do that through creating innovative financing vehicles. But we don't want to lose sight of the fact that energy efficiency really should be the first thing we do, is to look at the existing building stock, which is if, you know, Wyoming is the Saudi Arabia of wind I might say existing building stock is the Saudi Arabia of energy efficiency. There is so much opportunity for us to go out and capture better energy efficiency in existing buildings. We've got to go after it.

Greg Dalton: We have to wrap up. I want to end by asking each of you quickly. What gives you hope, what gives you fear thinking about the climate challenge in front of us? Mark Jacobson.

Mark Jacobson: Well, what gives me hope is if we do, if we can get to a 100% clean renewable

energy, then by 2050 we've found through simulations of carbon dioxide that by 2100 we can get between 350, 400 parts per million. So there is hope and then the temperature will lag behind that, but we can solve the problem if we put our mind to it. The problem is if we don't put our mind to it full throttle and actually get to 100% by then, then all bets are off the table and things will just get worse.

So the problem really is from the climate point of view that is much worse than people think because half of all global warming is being hidden by air pollution particles worldwide. So if we actually cleaned up all air pollution particles, all of a sudden we double the amount of warming. So this means that we have to eliminate not only the pollutants that cause the particles, but the greenhouse gases simultaneously if we want any hope to actually reduce the climate problem. It's such a serious problem and most people don't take it so seriously and but looking at the problem -- we really need to go to this 100% there is no other solution to the climate problem. It really needs to be done but the thing is, it can be done with existing technologies put to scale.

Greg Dalton: Steve Malnight, hope and fear?

Steve Malnight: Well, from a hope perspective, I was very fortunate to along with Tony Earley go to Paris in the climate conference as part of the California delegation and tell the story of California. And I think what gives me hope is that it's very clear that I think we have we may not be going as fast as we all want, but that debate about should we go at all is kind of over. And we are committed, there is ideas coming from all over. I saw sub regional organizations and subnational organizations talking about the innovation and creativity. I saw people from all over the world talking about it and I came back truly inspired and very hopeful that we're going to accomplish this goal.

The thing that gives me some sense of fear I will say, I mean in California I'd mentioned this earlier. I think we have an incredibly important role to play on demonstrating the leadership path. It's vitally important that we get it right. It's vitally important that we don't lose sight of making sure every California customer can come along because if we leave people behind here it's not going to be sustainable. We've got to make sure we keep focus on the cost, the affordability for our customers that people can both pay for it and breathe the clean air. And I fear that if we lose sight, we lose our opportunity to lead.

Greg Dalton: Mark Ferron, hope and fear?

Mark Ferron: I'll start with the fear. And when I was appointed to the Public Utilities Commission, I remember Governor Brown looking at me and saying don't screw it up.

[Laughter]

And so that's the thing that worries me. Like Steve, if this gets messed up and particularly if it's ascribed to renewable energy we could set things back by years or decades. So I think it is vitally important that we make these changes that were bold but that we don't screw it up. In terms of hope, like my two kids are sitting in the second row here. I think that's the thing that gives me the greatest hope, not just those two, but if you look --

Greg Dalton: No pressure kids.

[Laughter]

Mark Ferron: Keep studying.

[Laughter]

But if you look at voters under 30, their number one concern is around climate. And I think that is where, you know, the next generation is going to need to really push the political process to get off the dime and start making real changes from a policy standpoint to move us where we need to go.

[Applause]

Greg Dalton: We've been listening at Climate One to Mark Ferron, member of the California Independent system operator. Mark Jacobson, Professor of Engineering and Environmental Engineering at Stanford and Steve Malnight, Senior Vice President of PG&E. I'm Greg Dalton. Our thanks to the audience here in the room, online, you can join the conversation on Twitter using our handle @climateone and listen to podcasts in iTunes. Thank you all for coming and for listening.