

# C1 Revue: Resource Revolution

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**Greg Dalton:** This is Climate One, a conversation about powering America's future. I'm Greg Dalton. Some of the world's largest corporations are moving from fossil fuels to clean energy. Even the former head of a large oil company sees a shift away from gasoline.

**John Hofmeister:** I have no doubt in my mind that the primary cars that will be bought in the 2030s will almost all be electric.

**Greg Dalton:** Some companies are trying to slow down that transition and others are trying to lead and profit from it.

**Amy Myers Jaffe:** The trend line is clear that we want to de-carbonize the economy. So the question is, what does that mean for companies and their performance?

**Greg Dalton:** We also will talk about the science behind wild weather. Up next on Climate One.

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## PART I

*Music: In*

**Greg Dalton:** Climate One is changing the conversation about energy, economy and the environment. I'm Greg Dalton. These Climate One programs were recorded in 2013 and 2014 before a live audience at the Commonwealth Club of California, a non-profit and non-partisan public forum in San Francisco.

The global energy economy is undergoing tectonic shifts. America is poised to be an oil exporter - something unthinkable a decade ago - and severe weather and climate disruption are driving a push toward clean fuels. On today's Climate One I'll talk with business leaders, scientists and authors about the path toward a prosperous and sustainable economy. We also will talk about what is driving the droughts, floods and other freaky weather around the country.

First we begin with nuclear power. In the 1980's environmentalists were railing against nuclear as dirty and dangerous. While storing spent fuel and preventing nuclear proliferation are still concerns, some former atomic opponents are now supporting it as a form of carbon-free power. Is that a bargain with the devil or simply climate pragmatism?

To explore this question I'm joined by Jon Koomey, a research fellow at the Steyer-Taylor Center for Energy Policy and Finance at Stanford University; Dave Lochbaum, director of the Nuclear Safety Project at the Union of Concerned Scientists; and Per Peterson, a member of the Blue Ribbon Commission on America's Nuclear Future.

Here's our conversation about the future of nuclear power.

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**Greg Dalton:** Dave Lochbaum, let's begin with you. What is the story of Fukushima? How did it really impact the nuclear industry and what are the most severe consequences have you seen?

**Dave Lochbaum:** I think the accident at the Fukushima revealed some vulnerabilities that need to be better managed so that it lessens the likelihood that we have that kind of problem here in the United States. The industry is also concerned about - as they implement these lessons learned - these upgrades that it doesn't distract from their focus on day-to-day safety of the plants. So it's the challenge of maintaining what you got and adding onto it with the Fukushima upgrades.

**Greg Dalton:** Per Peterson, what do you think has been the lessons of Fukushima and how has it affected the global industry?

**Per Peterson:** I think that there has been some significant impact from the Fukushima accident. In the end, you can integrate those lessons into the design of new plants and probably the most important feature that we've introduced into the new U.S. designs is what's called passive safety. That is, the ability for the plant to shut down and remove decay heat without needing external sources of electrical power, which was ultimately the primary cause of the damage to the plants at Fukushima.

**Greg Dalton:** And how many of the U.S. nuclear plants have fully implemented passive power so that a Fukushima can't happen here? Because the problem is, you know, the storage in the basement gets flooded and it knocks the whole thing up. So -- Per Peterson?

**Per Peterson:** Our current plants don't have passive safety and it's not really practical to back-fit them with those capabilities but what we're doing is to introduce additional equipment and capabilities so that they can cope with essentially indefinite loss of electrical power supply and still not have fuel damage or release radioactive materials. With new plants you have a flexibility to actually make significant additional improvements.

**Greg Dalton:** Jon Koomey, how did Fukushima affect China, Germany, other countries? Did they take their foot off the gas on nuclear or did they keep going ahead?

**Jon Koomey:** For some countries like Germany, they did take their foot off the gas and changed their policies. In China it seems like they are forging ahead as far as I can tell.

**Per Peterson:** Certainly the Chinese have the largest and most rapid program today for the deploying new reactors and they're working with a wide variety of technologies including essentially every option that we're knowledgeable about that doesn't use water as a coolant.

**Greg Dalton:** The former head of the U.S. Nuclear Regulatory Commission I think is involved in overseeing the nuclear reform initiatives in Japan and he actually said that it's the water that keeps him up at night, what are they're going to do with the water, all the water cooling going out into the

ocean. Dave Lochbaum?

**Dave Lochbaum:** Their biggest problem is they have a lot of groundwater intrusion into the plant that then becomes contaminated and they can't discharge it, so it adds to their backlog of contaminated water. Over 80 million gallons of water has to be dealt with.

**Greg Dalton:** Let's talk about the state of the U.S. industry. A lot of reactors, about a 103, 104 reactors built in the 60s, 70s going back to the 50s even. A couple of new ones in the south part of the U.S. Jon Koomey, how would you describe the health of the U.S. nuclear industry today?

**Jon Koomey:** The history has some great success but also some serious issues. We have very high costs. No one expected that it would cost that much. There were high interest rates, there were cost overruns, there were structural issues. And so, some of the changes that have been made in the regulatory process and in the industry were meant to deal with some of these issues. The question remains whether those changes will be enough to allow the industry to build plants on time and on budget.

**Greg Dalton:** And how about regulation? Oftentimes, the industry would try to say that it's the regulators' fault because they make it hard or there's red tape. Does government bear some of the responsibility for some of the cost overruns? Dave Lochbaum?

**Dave Lochbaum:** Typically, it's not a matter of regulations driving the cost up so much as the companies that mismanage their activities and run afoul of the regulations. Time and time again it's been mismanagement that causes nuclear power plants to be shut down for extended periods. We've had 50 reactor shutdowns of over a year since the Three Mile Island accident. We estimate the cost of each of those to be nearly \$2 billion for electricity that was not generated.

**Per Peterson:** I would add that there are other industries that are heavily regulated like biotech, commercial aviation and commercial space launch which have managed to be far more innovative than what we've seen within the nuclear sphere.

**Greg Dalton:** Are there any plants in the U.S. that the Union of Concerned Scientists think ought to be shut down? Dave Lachbaum?

**Dave Lochbaum:** Well, Diablo Canyon and Oconee would be strong candidates, yes.

**Greg Dalton:** Diablo Canyon because it's on earthquake fault?

**Dave Lochbaum:** The fact that it doesn't meet the fire protection regulations for the minute that it's ever operated gives us a little cause for concern.

**Greg Dalton:** And why does the Nuclear Regulatory Commission allow that to continue operating?

**Dave Lochbaum:** Diablo Canyon is not alone. Roughly half the plants in the United States don't meet fire protection regulations that were adopted because of a fire in 1975 at the Browns Ferry plant. I don't know why the Nuclear Regulatory Commission chooses not to enforce its regulations.

**Greg Dalton:** Per Peterson, is the Nuclear Regulatory Commission a lapdog more than a watchdog?

**Per Peterson:** When you operate a nuclear plant, the most important thing is to make sure that everybody who works at the plant is willing to report problems. There is this natural tendency to

want to punish any mistake no matter how minor, which in the end, can end up causing you to not report mistakes. We have to encourage the reporting of problems and at minor levels so that they get fixed.

**Greg Dalton:** How much would it cost to be fire-compliant?

**Dave Lochbaum:** \$40M at Diablo Canyon is the estimate by the company. The NRC's senior managers testified to the commission that the fire hazard represents 50 percent of the core meltdown risk at the average nuclear power plant, which means it's equal to all other hazards combined. And that's if you meet the regulations. If you don't meet the regulations, the risk management gets worse.

**Per Peterson:** I think we need to step back a bit and look at the global picture for nuclear technology. Because the United States arguably has been most innovative in areas such as introducing improved approaches to safety and the design of new plants and other features that I think we'd like to see deployed worldwide making sure that U.S. can better export technologies to countries that meet requirements for non-proliferation, security and safety.

**Greg Dalton:** So we're a good actor and we out to stay in the game and not be marginalized is what you're saying? David Lochbaum?

**Dave Lochbaum:** We did a report in 2008 called "Nuclear Power in a Warming World" and the safest -- the best reactor we evaluated was the EPR -- evolutionary power reactor.

**Per Peterson:** Well, I would disagree [crosstalk]

**Greg Dalton:** Which is from where? Oh good. We're getting somewhere now.

**Dave Lochbaum:** It's from France.

**Greg Dalton:** France?

**Dave Lochbaum:** The U.S. is not at the lead of the safest reactors. EPR is way ahead.

**Greg Dalton:** How about China? China is the biggest deployer right now of nuclear technology. Are they safe?

**Dave Lochbaum:** Their biggest problem is they're building U.S. reactor technologies instead of the EPRs.

[Laughter]

**Greg Dalton:** Dave Lochbaum is director of Nuclear Safety Project of the Union of Concerned Scientists. Our other guests today at Climate One are Jon Koomey from the Steyer-Taylor Center for Energy Policy and Finance at Stanford; and Per Peterson, professor of nuclear engineering at UC Berkeley, I'm Greg Dalton.

Let's talk about waste; Yucca mountain didn't work out so well. What is the waste solution for nuclear waste? Right now, it's kind of lots of little pools all over the country. How is that going to be solved? Per Peterson?

**Per Peterson:** Well, the United States -- we're at a standstill right now for political reasons with respect to our program for waste and that's really a shame. What we know is that no matter what you do within fission energy systems, there's no way you can avoid the need to develop geologic disposal capability. So the challenge has been developing that kind of disposal. In the United States, right now we're pretty much at a political logjam that Congress needs to break.

**Greg Dalton:** Isn't the waste that's stored at the nuclear sites now vulnerable to the types of things that are in these pools, that sort of thing, it's not a long-term solution.

**Dave Lochbaum:** Roughly 75 percent of these spent fuels is currently in pools, wet pools. Twenty-five percent is in dry cask. Our analysis shows that you can actually flip those numbers and accelerate the transfer from pools to cask which will reduce the safety and security threat of the fuel lots in the pools. You would increase the safety and security threat of the cask but much less than the reduction on the pool side. That's what we'd recommend doing.

**Greg Dalton:** I'd like to talk about the liability shield, the risk that taxpayers are bearing for nuclear power plants.

**Dave Lochbaum:** The new reactors that are said to have passive safety systems and things like that, we've asked their owners to opt out of federal liability insurance. If they're really as safe as they claim, let them go down to State Farm and get their own liability -- as long as my money is backing up their claims, I'm going to remain skeptical.

**Greg Dalton:** Jon Koomey?

**Jon Koomey:** This is a subsidy, yes. Probably people wouldn't build reactors without it. And the question is then what is your alternative. You can't just look at one technology and say "Here's this subsidy." That's a bad thing. You have to look at the whole life cycle for all technologies.

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

**Male Participant:** Right now about 40 percent of our electricity in the United States is produced by coal and about 20 percent by nuclear. If you look out to 2030, maybe 2040, how would you see those ratios changing? Can nuclear displace coal?

**Greg Dalton:** Thank you. Per Peterson?

**Per Peterson:** You can't answer that question without first of all asking the question, "Are we going to have any sort of tax on carbon or carbon control?" That would make an enormous difference. But if we did have a carbon tax, then I suspect that you would see new nuclear and further expansion of wind and solar as well.

**Jon Koomey:** I think --

**Greg Dalton:** Jon Koomey?

**Jon Koomey:** I think actually that at least new wind installations are coming in now at about five cents per kilowatt hour for new builds. And the cost of wind and solar has certainly been coming down very rapidly. So, even in the absence of a carbon price I think you will see increasing pressure on coal and natural gas. But with a carbon price, things will go much more quickly.

**Greg Dalton:** Interesting contrast. Wind and solar prices down, nuclear prices going very much in the other direction.

**Greg Dalton:** Let's have our next audience question, welcome.

**Dave Madison:** Hello. I'm Dave Mason with Citizens' Climate Lobby. We have Mark Jacobson's and Mark Delucchi's analysis that the entire world can be powered by renewable energy in 20-40 years. That's without fossil fuel or nuclear. Given the considerations of cost, safety, waste, need for public subsidy, I'm wondering why we're talking about nuclear power instead of talking about a carbon tax and letting our entrepreneurs really get the renewable energy going?

**Greg Dalton:** Per Peterson? Why do we even need nukes?

**Per Peterson:** While wind has a low production cost, the daily average production varies day to day by a factor of 100 over the course of a year, so we just do not have affordable storage technologies that allow you to make this work. There are risks that that we'll end up stuck with a substantial amount of our electricity continuing to be generated by fossil plants that are operating during those periods of time when the wind and solar are not available.

**Greg Dalton:** Jon Koomey?

**Jon Koomey:** Within 20 years or so, you could have roughly a third of the electricity associated with these variable sources with much less storage than we thought. So I think part of what has to happen here is that we need to learn to be a lot more clever in how we operate the grid, we need to be smart about forecasting, because you can actually, a day ahead, pretty reliably forecast wind. And so, we can operate electric grids with very substantial fractions of variable resources.

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**Greg Dalton:** We've been discussing nuclear power in the age of climate chaos with Jon Koomey, a research fellow at the Steyer-Taylor Center for Energy Policy and Finance at Stanford University; Dave Lochbaum, director of the Nuclear Safety Project at the Union of Concerned Scientists; and Per Peterson, a member of the Blue Ribbon Commission on America's Nuclear Future.

You're listening to Climate One.

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## **PART II**

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**Greg Dalton:** LED light bulbs and electric cars are two new technologies that are changing markets and helping reduce carbon pollution. What other innovations are on the horizon?

With me now are three business veterans: John Hofmeister is former president of Shell Oil Company and founder of Citizens for Affordable Energy. Amy Myers Jaffe is the executive director of Energy and Sustainability at the U.C. Davis Graduate School of Management. And Matt Rogers is the director of McKinsey and Company and co-author of the book: *Resource Revolution, How to Capture the Biggest Business Opportunity in a Century*.

Here is our conversation about making money in the move to clean energy.

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**Greg Dalton:** Matt Rogers, let's talk about a hot planet with nine billion people. How are we going to feed and fuel that planet?

**Matt Rogers:** As we worked with business executives, they were struggling with this issue. If you see two and a half billion new people entering the middle class, 9 billion total people on the planet you say. My goodness, we are going to run out of resources and at the same time the resources are getting harder to extract. And we came to a conclusion that in fact it was an enormous opportunity. The combination of information technology with traditional industrial technologies actually was unlocking a set of business opportunities that were very large and that would mean that we could change the way we both produce and use resources in a way that would allow us to meet the needs of two and a half billion new middle class without seeing either the economic or the environmental disaster that a lot of folks thought was going to happen.

So if I can just use a simple example. This is a replica of one of the original light bulbs that Edison produced. When it came out, it cost 20 dollars. It cost 8 dollars per hour to run and it lasted for 15 hours. They delivered it in an egg carton because it was so precious. And yet this little light bulb ended up changing the world. Now if you go to the Ace Hardware over there today, you can buy this, which is an LED light bulb with a radio transmitter inside that you can download the iPad app to control this light bulb from your touch screen. This thing uses one-tenth of the power to achieve the same goal, and what we are seeing in industry after industry is this kind of 10x productivity opportunity. And when you see it happen in autos and in lighting and in oil, you begin to say, "Hey, we are going to change some of these markets." And that's what managers need to be ready for.

**Greg Dalton:** And you write that right now LED light bulbs are about 2% of the market, you think they'll be 80% by 2020? That's a big reduction in energy demand, less electricity to run those things.

**Matt Rogers:** The electricity demand in the United States grew by between 6% and 10% each year for 100 years. But with the introduction of things like the LEDs and other control technologies, we will likely see electricity demand go down even as we see electricity services increase in the market place. That changes the fundamental economics of the industry.

**Greg Dalton:** There is a joke about how many people it takes to screw in an LED?

**Matt Rogers:** So how many people does it take to screw in a light bulb? None. Grandma put it in 25 years ago and it's still growing strong.

**Greg Dalton:** Amy Jaffe, do you agree that energy demand will go down in the future and technology will bring this kind of tremendous savings?

**Amy Myers Jaffe:** I definitely believe that. We can see it here in the United States. Gasoline use and actual vehicle miles traveled in the United States has been falling, not rising as has had been previously predicted. And when you look across the country, it's a very small number of cars that people are buying that are electric or electric plug-in or partial electric hybrids, and so that technology hasn't even really hit yet. So I think that these revolutionary changes in automobile technology are really going to change the demand outlook for oil and really make real serious differences in demand trends here and places like China and India and other countries.

**Greg Dalton:** John Hofmeister, will electric vehicles disrupt the oil industry?

**John Hofmeister:** Whether it will completely disrupt the oil industry I don't think it will. But yes it would radically reform the oil and gas industry as we know it. My view is middle class families can't really spend that much more on gasoline. What we do is convert our existing cars as well as all new cars going forward to flex-fuel vehicles and we dramatically increase the amount of alcohol fuel that operates in an internal combustion engine the same way gasoline does, until we can electrify more of the fleet. I have no doubt in my mind that the primary cars that will be bought in the 2030s will almost all be electric.

**Greg Dalton:** Matt Rogers, There's a term that is seen about these days called "peak car." Tell us about peak car and what that tells us about mobility and disruption.

**Matt Rogers:** We think that this combination of substituting different fuels, electrification or other substitutes, the ability to share automobiles and then a whole set of the things that the Google car introduced in terms of automation technology that now every one of the big auto makers are adopting mostly in the 2017 model year are going to make the need for fewer cars but they will be much safer and much more efficient. So all of these things pieced together, we see a very different transportation network than we could have even imagined a decade ago.

**Greg Dalton:** But there are still teenagers in India and China who want to get a new car and is that where the growth will be and then what does it mean about the carbon question? Matt Rogers.

**Matt Rogers:** So clearly you are seeing growth in India and China. But what you'll see are this next generation adopting transportation technology in fundamentally different ways than we've had in the past, and I think there will be incremental demand but it won't be nearly as large as I think some of the forecasts even five years ago would have suggested.

**Greg Dalton:** What are some industries that are going to be disrupted most by this? What are the biggest innovations and what industries are really going to have their world rocked by this?

**Matt Rogers:** Well, we clearly talked about the automotive industry and each product cycle is bringing in a new set of efficiency technology, automation and control technology. And so I think you'll see a change there. We will see change in the electric power sector and your standard home have some sort of ability to sell back into the grid substantially more distributed generation, solar and other resources that sell from homes back into the grid. So that changes the way that whole industry operates. Uh, same thing by the way in building. And what you are seeing now in China importantly are a set of companies that design in a modular way that you are going to essentially do it all with almost no waste and they assemble it in modules and deliver it to the site. There are companies are now building large buildings in weeks rather than months because of the efficiency that comes from taking a much less resource intensive way to construction. So it's happening in industry after industry on a global basis.

**Greg Dalton:** Amy Myers, let's ask you about fracking and how that's disrupting and changing the energy industry in the United States.

**Amy Myers Jaffe:** It's brought about an incredible change because this dramatic technological breakthrough that we are having in the United States to be able to produce the oil trapped in the actual source rock. Well we all know where the source rock is. It's everywhere. This oil is everywhere. Um. everybody is used to having all of that oil produced in Texas or Louisiana or



Alaska, places where it doesn't affect your everyday life. But now this shale whether it's oil or natural gas could be produced in California, in Ohio, Arkansas or in Colorado or in Pennsylvania, so..... we are bringing it closer to home.

**Greg Dalton:** In people's backyard, it brings it closer to home. It is a disruption. But what about the water got consequences and other sorts of things? That's something...

**Amy Myers Jaffe:** Well, you know, if I'm doing it well and I don't have any kind of problems with my engineering system, then theoretically there should be no problem with the water. You know, am I disposing of it carefully or am I throwing it in someone's backyard because that's the cheapest thing to do? Am I pouring the cement correctly and am I using the highest quality cement or not? Or you know believe it or not here in California in some places where there's oil production we take some of this water from under the ground that we've used when we are producing oil and we just put in an unlined pit on the ground. And this is not a good thing. So getting every place across the country to use these best practices, you know, is a challenge. But the oil industry needs to take on my opinion the responsible role in this sense. If they don't take a responsible role, then more and more communities will opt out, will say, "You know what, we don't want this kind of drilling here. We don't want to undertake the risk." So it really is about whether the industry can show that it can rise to the top level of environmental performance.

**Greg Dalton:** John Hofmeister, can the American people trust energy companies to do the right thing or will government have to force them?

**John Hofmeister:** Well I think it is a trust and verify response. So trust is not enough but you can certainly verify whether people are following well-articulated regulations. And if some companies are unwilling to step up to that, let them go do something else. Because I think that there is a social responsibility associated with the opportunity to extract natural resources for a profit and that social responsibility is, "Don't ruin my backyard."

**Greg Dalton:** Does that make you popular in Houston down at the bar where you're talking with the oil guys. I mean, do they want more regulation?

**John Hofmeister:** When I am in an industry convocation and I say, "You deserve to have your license taken away from you, you should not be allowed to operate if you can operate to the best practices." There are some people in the room who wish I'd go away. But there are people in the room say, "Speak more loudly. Help us help ourselves." Because there is such a demand for energy, we can't get there from here on the path that we're on and so we need new paths, one of which is more oil and gas so that we can continue to grow our economies and provide jobs for people.

**Greg Dalton:** We are talking about America's energy future at Climate One. I'm Greg Dalton and our guests are Amy Myers Jaffe, executive director of Energy and Sustainability at the U.C. Davis graduate school of management, Matt Rogers from McKinsey and Company and John Hofmeister, former president of Shell Oil.

**Greg Dalton:** Amy Myers Jaffe, there's something called the carbon bubble. Scientists say and even some investment banks have said if we burn all the carbon and hydrocarbons in ground, we will fry the planet, and that some of these assets, refineries, pipelines, etc., will become stranded assets.

**Amy Myers Jaffe:** So in 2009, we had a breakthrough science article, became a seminal article in the industry, written in Nature by a group of scientist. And they said in order for us to hold at a two-degree warming, we're not gonna be able to burn the fossil fuels that we're using today. We have to

make a dramatic shift. Interestingly the stock market did not actually ignore that article. And 63 of the largest U.S. oil and gas companies shed 27 billion dollars in their share price. So it is not correct when people say, "Oh yeah, yeah, yeah, you know, unburnable carbon. It's a non-issue." You know, it's not a small issue. But there is the practical concern which is that, a lot of people still have a car and it still runs on gasoline, right? So the question really is gonna be how much renewable energy resources we have here in the United States and what is the policy framework that's gonna come in to turn to a 100% shift to those resources.

**Greg Dalton:** Shell made a big play in the Arctic. Do you think that was a mistake? Will there be some stranded assets in the arctic?

**Amy Myers Jaffe:** Well, there will be if they make the mistake of investing there. I mean, you know, in the end, the trend line is clear that we want to de-carbonize the economy. Even the polling in China shows agreement among younger generation people with that trend line. So the question is, what does that mean for companies and their performance? If you are a company and you're doing a project where you're gonna spend 10 years trying to develop that project in the Arctic or in the deep water in Brazil or in the Russian Arctic, and then it's gonna take you 20 years to actually produce the oil and gas. You know, if I were picking the stock, I'm not sure I'd want to own that stock.

**Greg Dalton:** Matt Rogers, is this gaining more acceptance the idea that we can't burn all the carbon we've been talking about?

**Matt Rogers:** Look at the valuation for most of the oil companies, for example, and, or coal company in the market today. The market actually is putting very little value on assets much beyond 10 years and so I think this is a forward conversation as opposed to a today conversation in that regard. And I think what we are observing now is this competition about who can develop these resources in ways that are the most economically attractive over long periods of time and part of that involves looking at resource and saying, I'm drilling a 30-year well and not a 5-year well and that changes the economics quite considerably.

**Greg Dalton:** John Hofmeister, are there some hydrocarbons that need to stay in the ground or we will fry the planet?

**John Hofmeister:** I think that we will move away from hydrocarbons as time progresses because we have better alternatives and they will be in the ground forever because we won't need them.

**Greg Dalton:** When you were heading Shell Oil in America, one of the biggest pieces of legislation was AB32 California's landmark climate change law signed by Governor Schwarzenegger in 2006. The oil industry opposed it, Shell did not, why?

**John Hofmeister:** Be part of the solution. There was no doubt in my mind that AB32 was gonna pass and you're either a player and you're gonna work with it or you're an opponent, you're an adversary and you don't count.

**Greg Dalton:** Being on the winning on side, the green side, has that benefited Shell since then?

**John Hofmeister:** By virtue of the fact that Shell is not the enemy in this case, I would say so. And my former company for a long time has been all about let's reduce the carbon in the atmosphere And that's been the whole case in Europe where my former company was a leader in trying to use cap and trade, trying to use other regulatory regimes and technology to reduce carbon.

**Greg Dalton:** So it sounds like a lot of the oil industry is fighting a losing battle or going to be on the wrong side of history?

**John Hofmeister:** Absolutely. Because it can't think beyond the next step of making money. One CEO told me he didn't know what my job was but his job was to work for shareholders. But I think there is something that goes beyond the immediacy of earning a profit for shareholders that speaks to the socially responsible requirements to operate in an ever evolving society and the dynamic is you work with others even those you disagree with to try to do what's best for all considered.

**Greg Dalton:** Matt, is it possible that things could change really quickly that some energy companies could lose money, end up on the wrong side of history as John Hofmeister just said?

**Matt Rogers:** Industry after industry is in fact changing very quickly. And I think companies that don't adapt quickly to the market that we're seeing will in fact get left behind. The rate of change that is occurring in these underlying technologies is so much faster than it has been for decades that if you are a manager and you are running one of these companies, it's coming at a pace that you've never seen in your career and so the ability to adapt and respond at a pace that is commensurate with the change that is coming is often too slow. And so, you know, what we saw at the last Industrial Revolution where a whole set of companies that went by the wayside because they didn't change fast enough

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

**Audience Member:** Yes, John Addison. Contrast the adaptation we may see if there's no price globally on CO2 emissions, on methane emissions versus the kind of innovation and adaptation we may see if there is a global price on CO2 and methane emissions.

**Greg Dalton:** Matt Rogers, will having a price on carbon drive innovation?

**Matt Rogers:** The commodity prices today are the single biggest driver of making that happen. Hundred-dollar barrel oil drives all kinds of innovation as does 16 or 18-dollar gas in Asia. That's been the biggest force for driving innovation. Very large innovation at a scale and a pace that is well beyond what any of the policy makers were originally thinking about.

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

**Audience Member:** When it came to transportation, all you talked about was re-engineering the car so we could fit more of them in the city, not re-engineering the city so that we would need less cars. Public transportation, much maligned and kicked around in Congress, Amtrak even with its huge ridership increases despite its poor amount of resources that has been given. When it comes to transportation, the U.S. is a third world country. And you're just trying to support that. You're keeping us back, these kinds of attitudes.

**Greg Dalton:** So Matt Rogers, the two and a half billion people that are going to move in to cities need to move in to a different kind of cities that are less car based or else we're in trouble.

**Matt Rogers:** No question about it. So we actually have some terrific new insights about how to set up cities that are dramatically less energy intensive, dramatically less resource intensive in all of their development. By the way, it links into water, it links into agriculture and how you make that work as well that are important in the design of cities.

**Greg Dalton:** John Hofmeister, the other piece of that is individual change, doing with less, less car based. Even if we redesign cities differently, there is a part there about behavioral change and even perhaps sacrifice.

**John Hofmeister:** Public transportation is a very critical part of the future of cities. But behavior change is hard. And changing behavior is something that is done perhaps generationally. Behavior change is so incrementally slow as to be I would say not even qualifying for the word evolutionary.

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

**Audience Member:** We've talked a lot about this 20-year horizon where we may have electric cars and a de-carbonized world. But there's this I think accepted concern that we can't let the climate change more than 2% Celsius but yet most of this emphasis we've heard today has been on 20 more years of profit making extraction from as many places now as possible. And this maybe 20 years can be spent in other ways not using anymore extraction.

**Greg Dalton:** Can we do this faster? Amy Myers Jaffe?

**Amy Myers Jaffe:** Average American keeps the car for 10 years, right? So the time loop of what it takes, you know, if we are a wealthy enough country that President Obama could stand up tomorrow and say, "Okay, cash for clunkers. I'm gonna pay back every American who will turn in their car in the next two years." That would be great. But the reality is it will take at least a decade to turn over the current car fleet. And the current car fleet runs on oil and, you know, that's just the way it is and if don't like that, we need to take that action ourselves.

*Music: In*

**Greg Dalton:** We've been talking about energy and climate with John Hofmeister, former president of Shell Oil Company; Amy Myers Jaffe, executive director of Energy and Sustainability at the U.C. Davis Graduate School of Management; and Matt Rogers, director of McKinsey and Company. You're listening to Climate One.

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### **PART III**

*Music: In*

**Greg Dalton:** Next we turn to climate science and severe weather that underline the need for a fuel change. Wild fires, droughts, floods and storms are already buffeting the economy. How big a roller coaster ride are we in for?

With me now are two of the country's top scientists. Jane Lubchenco was the administrator of NOAA for 4 years under President Obama. That's the National Oceanic and Atmospheric Administration. Currently she is a professor of marine biology at Oregon State University. Ben Santer is a climate scientist at Lawrence Livermore National Laboratory and the author of several influential studies on human-caused global warming. Both are recipients of MacArthur Genius award.

Here's our conversation about the science of wild weather.

*Music: Out*

**Greg Dalton:** Jane Lubchenco, your time in Washington did see a lot of extreme and severe weather. Tell us about that period of time.

**Jane Lubchenco:** The four years that I was at NOAA which, of course, has the National Weather Service as well as keeping all the climate records, we had the most extreme four years of weather ever in U.S. history as far back as the records go for different categories. We had 770 major tornadoes in those four years. We had 70 Atlantic hurricanes, 6 major floods, 3 tsunamis, record-breaking snowfall and blizzards, drought, prolonged heat waves and wildfires. Every different possible category of extreme weather we had in spades. But I think that that extreme weather actually changed a lot of people's opinions, a lot of people around the country started saying, "What the heck is going on?"

**Greg Dalton:** Ben Santer, are there human fingerprints on this kind of weather? How do we know if Mother Nature is not just slapping us around a little bit?

**Ben Santer:** Yes, we do know. For many years, people primarily were interested in looking at broad brush changes and average climate. But after the European summer heat wave in 2003, the game changed. And we can now, as scientists, make informed statements on how we're changing those likelihoods.

**Jane Lubchenco:** When a baseball player starts taking steroids, there's a much greater chance that he's going to be hitting lots of homeruns and some big homeruns. Now, that doesn't mean you can point to any particular homerun and say, "A-ha, that homerun is because he is taking steroids." But the pattern of more and larger is attributable to his taking steroids. And I think by analogy, what we are seeing was some kinds of extreme weather is weather on steroids, weather on climate steroids.

**Greg Dalton:** We know a thing or two about steroids and ball players here in San Francisco. Ben Santer?

**Ben Santer:** I think in terms of changes in the frequency of these events, the jury is still out. In terms of the intensity, I think there is relatively good understanding, that we should expect to see intensification of hurricanes and typhoons.

**Jane Lubchenco:** Heat waves are one of the most damaging natural disasters. And I think there is increasing evidence that the very, very large heat waves that we are seeing, expect to be seeing more of those and lasting longer.

**Greg Dalton:** The winter of 2013 saw some pretty strong cold periods What do you say to someone who says, "It's freezing, global warming, hah!" Ben Santer?

**Ben Santer:** Well, I tell people, "That's the phenomenon we climate scientists refer to as winter."

[Laughter]

**Ben Santer:** We know that there is this rich year-to-year and decade-to-decade natural variability of the climate system. That's not going to go away. That's the backdrop against which we're trying to identify some slowly evolving human-caused warming signal.

**Greg Dalton:** Let's talk about oceans. The Arctic often comes up. Jane Lubchenco, why is the Arctic

so important in the overall scheme of understanding and predicting climate disruption.

**Jane Lubchenco:** The Arctic is really important because of the role that it plays globally. And the fact that it is warming twice as fast as the rest of the planet. There are some hypotheses that the melting of the Arctic and then the changes in reflectivity because the ice is no longer there and the ocean is absorbing more of the heat's energy may have consequences for the path of the jet stream.

**Greg Dalton:** And why should we care about the jet stream?

**Ben Santer:** Well, it sort of steers mid-latitude storms so the location and the strength of the jet stream is an important factor in determining where storms are.

**Greg Dalton:** So it could change the temperature in Europe, for example...

**Jane Lubchenco:** Or the temperatures here. I mean we've had this real spate of cold weather. The jet stream is much farther south than it typically is. But the question is whether that movement is really being impacted by changes in the Arctic.

**Greg Dalton:** One ocean impact getting a lot of attention is acidification. Why is that important? What impact will that have on ecosystems and human food chain?

**Jane Lubchenco:** Oceans have been actually doing us a major favor by absorbing between a quarter and a third of the carbon dioxide that we have put in to the atmosphere. But when oceans absorb carbon dioxide, there's a change in the chemistry of the ocean and oceans become more acidic. In the past 250 years, oceans have become almost 30 percent more acidic. Some, but not all species, are very sensitive to changes in pH, in the level of acidity. In particular, those marine plants and animals that have a shell or a skeleton that is made of calcium carbonate or chalk, the shell is more difficult to make when conditions are more acidic and it erodes more rapidly. And so things like oysters, mussels, clams, also corals, many, many different groups of animals in the ocean but also some very important plants that have shells or skeletons.

The sobering news is that we are already seeing impacts in nature not just in simulated situations in laboratory tanks. There is a very small marine snail called a sea butterfly that's about the size of a lentil bean. And these small animals make shells. And the shells are already becoming weakened and they're sort of eroded. Those sea butterflies occur in many places in the ocean and they're very, very important food sources for salmon, for example, and for mackerel.

And the one ocean acidification story that a lot of people are very concerned about has to do with coral reefs. Corals are very, very sensitive to changes in ocean chemistry. The prediction is that by the end of the century, we won't have active coral reef formation.

**Greg Dalton:** That impacts many, many subsistence fishermen around the world who rely on the fish that eat that coral, and what that means for ecosystems and economies, people who are living close to nature. What are the impacts of that?

**Jane Lubchenco:** Between one and three billion people depend on seafood for their primary source of protein and a large fraction of those are in the developing world. Sixty percent of Indonesians depend on seafood for their primary source of protein and it's dependent on the reefs. And so there may very well be some very serious consequences.

**Greg Dalton:** We're talking about climate impacts at Climate One. I'm Greg Dalton. Our guests are

Ben Santer, a scientist at Lawrence Livermore National Laboratory and Jane Lubchenco, former administrator of the National Oceanic and Atmospheric Administration.

Let's talk about the ways out, the solutions, for this and some of the rays of hope that you see for a different path forward. Let's start with Ben Santer.

**Ben Santer:** People often ask me, "How can you go into work in the morning? Aren't you profoundly depressed?" For me, one of the answers to that kind of question is that, over my lifetime as a climate scientist, I've seen these twin signals. One is this signal in the physical climate system: warming of the ocean, warming of the land surface, warming of the atmosphere. But in tandem with that physical signal, I think there has been a signal in public understanding. We've moved from 20 years ago we don't really know whether it's warming or not to warming is unequivocal. We've moved from denying the science to informed discussions on what to do about it. That makes me extremely hopeful, actually, that people who never would have listened to me, even five years ago, are now willing to listen to the science, pure, unvarnished account of what we know with confidence, what we don't know, and why they need to care about it.

This makes me hopeful: Climate One. This is a safe place where people with very different perspectives on the science and the solutions can have a discussion on what to do about it? And the reality is that individuals, companies, countries who figure out cheap, efficient ways of providing low-carbon energy are going to be the leaders of the 21st century, That makes me hopeful. And we have a real choice here in the United States, either to be leaders in that endeavor or to be followers.

**Greg Dalton:** Jane Lubchenco?

**Jane Lubchenco:** I think that there are tipping points in people's behavior and understanding as well as tipping points in the physical climate system. The extreme weather that a lot of people are seeing is changing opinions. I think that that's hopeful. Many more people are beginning to see climate not as an economic issue, not as a political issue but as a moral issue. And changing the way we think about the problem, I think, is part of the solution.

**Greg Dalton:** What can an average person do?

**Jane Lubchenco:** People can work together with like-minded individuals on reducing carbon emissions. Be politically active. Pay attention to what your elected representatives do. Help school kids understand what's happening. You know, one of the things that also gives me hope is the number of young people that are very concerned about this issue and really want to change it.

**Greg Dalton:** Ben Santer, what can an average person do?

**Ben Santer:** Inform yourself about the science. We need an informed scientifically savvy electorate. Because ultimately, to get back to the wit and wisdom of Harry Potter, "There will come a time when we must all decide between what is easy and what is right." And we're approaching that time where we have to decide whether we're just going to follow the path of least resistance in terms of emissions of greenhouse gases, or whether we're seriously concerned about the kind of world we want to leave behind for our kids and grandkids.

So having some knowledge of the likely outcomes; what is the climatic shape of things to come for sea level, for temperature, for rainfall, for extreme events, for their statistics, their intensity, their frequency? In the end, that basic knowledge and that interest in the science I hope will enable us to do what is right, not what is easy.

**Greg Dalton:** Let's go to audience questions. Welcome to Climate One.

**Audience member:** I'm Holly Kauffman and my question is, it was my understanding that we were going to be losing some important weather and climate observation satellites, could you explain to us the importance of those satellites and what the status is whether we have them or not?

**Jane Lubchenco:** There are series of satellites that are equipped with either weather and/or climate instruments that give us information that's invaluable that allow us to predict the weather as well as track climate change. And over 90 percent of the data that go into the weather models come from satellites. So it's critically important that we have those satellites. The program has become more and more expensive through time and it's been a real challenge to get it funded at all. I was on the Hill talking to members of Congress about how important these weather satellites were and one member of Congress said to me, "Doctor, I don't need your weather satellites, I've got the Weather Channel."

[Laughter]

**Jane Lubchenco:** And I thought, "Boy, do I need to take a few steps back and start all over again." Now if it's that hard to get weather instruments funded and weather satellites funded, it's a lot harder to get climate instruments on satellites. And the budget cuts have actually created some real havoc with the satellite programs. It's delayed them, which increases the likelihood that there will be a period of time where we won't have that coverage, and we'll be able to do weather forecasts that are sort of the quality that we had 30, 40 years ago, not the quality that we have today. And there's real danger that many of the climate instruments are not going to be funded and not going to fly on satellites.

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

**Audience member:** Thank you. My name is Anne Arquit. Do you think that we're on track to stay within the two degrees centigrade warming that sort of has a political and scientific consensus that that's sort of a safe level for the planet? And if not, what are the scariest impacts that we should be really worried about if we don't make two degrees?

**Ben Santer:** There are a lot of things that are of concern. Ocean acidification, that's real. It's happening now. The warming of the Arctic. The thawing of permafrost. Release of methane to the atmosphere from high latitudes in the Arctic, that's of concern. Perhaps Wally Broecker said it best, "Climate is an angry beast and we're poking it with a sharp stick." We don't really know very well where that level of dangerous anthropogenic interference is and are unlikely to do so for a number of years. So it's all about risk management. What level of risk are you prepared to accept for some of these bad things to happen? That's what it boils down to.

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

**Audience member:** My name is Ashley Cryan and I'm curious to know what your opinion is on geo-engineering and what the potential might be for a technology to play a part in some of the solutions?

**Greg Dalton:** Geo-engineering, break the glass, pull the switch. Ben Santer?

**Ben Santer:** Geo-engineering has received a lot of attention in the last five or six years. The idea being that we can do something to counteract the warming caused by human-induced changes and



levels of greenhouse gases in the atmosphere. To me, that's always seemed a little problematic.

I first encountered this at Lawrence Livermore National Lab about 15 years ago. Edward Teller invited me into his office and wanted to talk about geo-engineering. He had the idea that one could inject sulfate aerosols into the stratosphere and reflect back some portion of incoming sunlight and counteract human-caused warming. I pointed out that after big volcanic eruptions like Mt. Pinatubo in the Philippines in 1991, scientists observed that these aerosol particles formed surfaces on which some interesting chemistry took place that was partly responsible for the depletion of stratospheric ozone, and depleting stratospheric ozone would be a bad outcome. So, I would not like to put all of my eggs in the geo-engineering basket and say, "We are confident that we know enough to find a technical solution."

**Greg Dalton:** Next question, welcome to Climate One.

**Audience member:** Hi. What do you feel are the top like three things we should be pushing our legislators to pass to reduce our carbon emissions?

**Greg Dalton:** Jane Lubchenco?

**Jane Lubchenco:** You know, I think the big one is some kind of legislation that either puts in place a cap-and-trade system or a carbon tax system.

[Applause]

**Jane Lubchenco:** But the likelihood of that happening in this Congress is not very great. And I think the question is how do we change the minds, either change the people or change the minds of the people who are there and it's one or the other.

*Music: In*

**Greg Dalton:** We've been discussing how to reduce the growing amount of carbon pollution that is disrupting our climate. Our guests were Jane Lubchenco, former administrator of NOAA and Ben Santer, a climate scientist at Lawrence Livermore National Laboratory. You're listening to Climate One.

Thank you for joining us this hour. Free podcasts of these and other conversations are available in the iTunes store by searching Climate One. Follow us on Twitter at climateone.

Please join us next time for another Climate One discussion about powering America's future.

[Applause]

**Greg Dalton:** Climate One is the sustainability initiative at The Commonwealth Club of California, a non-profit and non-partisan organization. I'm Greg Dalton, the Executive Producer and Host. Jane Ann Chien is the producer. Alyssa Kjar is the Assistant Producer. The audio engineer is Will Llewellyn and editor is Claire Schoen. The Commonwealth Club CEO is Dr. Gloria Duffy.

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