SAMUEL LAWRENCE FOUNDATION

# Full Transcript

**Radioactive Waste:**
Growing Threats,
Emerging Solutions.

July 24, 2024
**Symposium**
**at UC San Diego**
Design & Innovation Building

## Opening Remarks

**Alison St. John:** My name is Alison St. John. I used to work for KPBS. I was a journalist for many years and covered San Onofre from 2012, when the plant was shut down prematurely because of new and badly designed steam generators, which leaked. So I'm going to try not to be a sergeant major, but we do have a lot of people to talk today, so I'm going to try and keep time and sort of move us along. So my first order of business is to say that we are very fortunate to have to kick us off the Margaret Leinen, who is the Director of the Scripps Institution of Oceanography, which, as we know, is one of the most respected research institutes in the world. She's also UC San Diego's Vice Chancellor for Marine Sciences and Dean of the School of Marine Sciences. So, Margaret, kick us off. Woo!

**Dr. Margaret Leinen:** Thank you. Hello, everyone. Welcome to UC San Diego, and this very new building, focused on innovation. And I think that's such a great token for this meeting. It's wonderful to see such a great group of people that are going to be able to talk to you today, as well as such a great turnout of people that are interested in this very important issue. And thank you to the Samuel Lawrence Foundation and the event organizers for including me and several representatives from Scripps Oceanography. So someone just before the session today said, "my husband wants to know what oceanography has to do with this topic". And as it happens, I was going to tell you exactly that. So our name is oceanography, but we're actually Earth, atmosphere, ocean and climate science and really branching into a number of other things, because the Earth is a system, and all of these are components

of it. And the ocean touches all of these elements. So a previous director, very famous director of Scripps, Roger Revelle, once said oceanography is anything Scripps does. So there you have it. Our mission is to understand and protect the planet and find solutions to our most pressing environmental problems. And responsible energy development is certainly one of those.

**Dr. Margaret Leinen:** And it's a great challenge of our time. And as we look forward to alternative solutions that can propel our society forward, we want those solutions to be ones that cause as little environmental harm as possible, hopefully no environmental harm, and that they not exacerbate climate change. So our scientists are experts who span all of these disciplines and a number of strategic research themes, including climate change impacts and adaptation to them, resilience to hazards, human health in the ocean, innovative technology for the planet. And as you see, all of those touch on this issue of energy development and safety, especially for a nuclear plant in the coastal zone. Scripps Oceanography is the home to the Keeling Curve, a record of atmospheric CO2 that started back in 1958 and is considered the foundation of our understanding of CO2 and its impact on climate. We also invented programs like Argo, which is a collection of autonomous floats in the ocean that autonomously send back profiles of the temperature salinity, in a profile of depth of 2000m every week. And there are almost 4000 of those. That rich, synoptic and persistent record of the ocean is the reason that we now know that the ocean is taking up 93% of the excess heat generated by our use of fossil fuels.

**Dr. Margaret Leinen:** So think about if the ocean were not taking up all of that heat. These are examples of the kinds of projects that are taken on at Scripps. Scripps also leads on research on natural hazards and resiliency to them, including earthquakes, tsunamis, some of the things that we worry about at San Onofre, wildfires, weather phenomena like atmospheric rivers and the impact that they have had and sea level rise. Scientists are leading research on developing early warning systems to improve forecasts for all of these, and to invent technology to monitor and observe these hazards and then develop strategies to reduce our susceptibility to the impacts of these hazards. Scripps geoscientists led research to examine earthquake and tsunami threats to San Onofre. This study included offshore research to understand the fault lines off the coast and seafloor topography to determine the tsunami threat. This research cannot be done in an isolated fashion. Not only do the various kinds of research have to inform each other, but we also have to do that in concert with those that use that information, whether those are local citizens, whether those are electeds, whether they're agencies, whether they're companies. And so we have a vibrant interaction with all of those sectors in talking about the research and really trying especially for research on topics like this, to co-design that research in a way that makes the information most valuable to the people who need to use it.

**Dr. Margaret Leinen:** So that's why it's so great to see such an incredible array of speakers. And we're going to need all hands on deck for this. We have a real challenge ahead of us with energy development. Energy needs are not diminishing, and recent estimates of the impact of AI on energy use suggest that it's going to accelerate, not diminish, over the near future. So on top of that, Earth just this week experienced its hottest day since 1940, a global temperature record. So I'm excited that you're going to hear from several Scripps scientists: James Day, who's a chemist working on isotopic chemistry; Jeff Severinghaus, who's a paleoclimatologist; and John Orcutt, who's a geophysicist and has been very interested in this issue, and in San Onofre especially. So I hope that we can assist you in understanding the context, the scientific context of this, and also learn from you about how to shape our research in the future so that it's most useful for you in solving problems like this. Thank you so much and thanks to the Samuel Lawrence Foundation.

## Morning Keynote: Opening Dialogue and Discussions

**Alison St. John:** As a journalist, I know how difficult it is to keep covering an issue that doesn't change. And the last time I covered this was like 4 or 5 years ago. And what's changed? I mean, you know, the stuff is still there. So, what I think is so important about this next panel is that we've got three guests who are going to talk about some things that are beginning to possibly move and change. I'd like to introduce the moderator of our next panel. Stephanie, would you like to come up? Stephanie Cook is a journalist who writes for Energy Intelligence, which is a site that describes itself as, "your essential guide to navigating the changing world of energy". She's also written for The New York Times and has done global coverage of the nuclear industry. Go for it. Thank you, thank you.

**Stephanie Cooke:** Great. Well, thank you to the Samuel Lawrence Foundation. Alison, I'd like to introduce our panelists.

**Alison St. John:** I realize I'm remiss that before you started, we were going to show a little video.

**Stephanie Cooke:** It's a video to set the scene of the San Onofre situation, which is kind of relevant to the entire day's proceedings. So I'll stand aside.

**Intro Video:** (Video Plays) We couldn't keep doing refueling and taking 90 fuel bottles and put them into fuel pool. There was no place to put them. They had to go into canisters. The canisters, you got to remember, have three circumferential welds that goes all the way around the canister and two longitudinal welds. In other words, a plate that's rolled, an eight foot plate, and we weld it longitudinally and then we round it up, we put the two together and then we do a circumferential weld, another circumferential weld for the cap on top and another one. So you got geez, I don't know how many feet of weld that is, but it's a lot of weld. Just so we understand what attacks metal. There's electrolysis that's dissimilar metals. Take two pieces of metal and weld them together, one that's less noble and the one that's more noble one is going to plate the other, especially in a chlorine environment. Then there's what's called crevice corrosion. Crevice corrosion is probably your biggest enemy. The reason for that is it's called crevice corrosion the chlorine starts eating the metal, especially in a salt water chlorine environment. And now you've got ambient air that's maybe it's 40 degrees one day, maybe it's 100 degrees the next and what happens is that metal keeps scratching. So you get what's called torsional stress. Torsional stress is like a coat hanger. Keep bending it back and forth and it eventually breaks, you know. And that canister is under a lot of pressure with 300 degrees.

**Intro Video:** In the loading process, there is a very large risk that those canisters were scratched as they slid down into their storage silo. I have come to realize that the handling of the most hazardous material known on the face of the Earth was, in fact, being handled like any other commercial waste product. Basic safety requirements have been waived or contorted in favor of expediency and cost.

**Intro Video:** I know as a engineer and as a machinist, that is not going to last ten, 20, 30 years. It's just not going to last. It can't. Not on the ocean.

**Intro Video:** Should something happen, it will leave portions of this country uninhabitable for not if hundreds, but tens of thousands of years.

**Stephanie Cooke:** The first speaker I'd like to introduce is Larry Agran, who served as a legal counsel to the California State Senate Committee on Health and Welfare. And he's also taught legislation and public policy at UCLA School of Law and the School of Business at UC Irvine. Larry also first served on the Irvine City Council from 1978 to 1990, including six years as mayor. So much experience in government. And before I ask him to speak to us, I wanted to say that he is going to be introducing some important and unprecedented legislation today for the state to start dealing, to come up with a plan to deal with SONGS. I also want to say to just set the scene. We all know that the federal government has kind of failed miserably on nuclear waste, but there has been a recent, even more disturbing, change in legislation advanced by the Biden administration called the Advance Act. And that changes the NRC's mission plan to prioritize the benefits of nuclear energy first over health and safety and the environment. This has been over years, watered down and watered down the prioritizing of human health and safety and environment. But this has actually, changed, switched the pendulum in the other direction, sort of compass point toward the benefits of nuclear energy. So I'd like, with that as a background scene setter, I'd like to ask Larry Agran to come and tell us about his legislation.

**Vice Mayor Larry Agran:** Thank you. Well, thank you very much. I want to first thank the Samuel Lawrence Foundation, Rita who was in touch with me, Bart whom I had a chance to meet in person finally this morning. This is an opportunity for me to try out something by way of communicating a policy approach, communicating a strategy that is a little new for most people. I can see from the people gathered here that a lot of us, certainly a lot of people here, have much more in the way of technical knowledge, understanding of the problem and so forth than I do. I think I may be able to offer an insight as to an initiative that could be undertaken that may begin to address the problem in a productive way. So I'm a long time local elected official in Irvine. I'm currently Vice Mayor. I'm actually running for Mayor this November. That's an aside, but I'm very committed to dealing with this San Onofre situation. We are 25 miles north of San Onofre, and ever since I was first elected way back in 1978, San Onofre has been a concern. So what do I bring to this problem? I think I bring the ability to remind people, first and foremost, what is the number one priority of government at the federal level, at the state level and at the local level? Anybody have an answer? Number one priority.

**Vice Mayor Larry Agran:** Yes. Keep the people safe. Keep the people safe. Number one priority. We should never lose sight of that. So with reference to San Onofre, I don't think I need to describe the problem here. I think others will be describing it. All you have to do is take a look at these photographs and you have to be an idiot if you don't understand, this is a problem. You've got to be concerned. If you have your head screwed on straight, you got to be concerned. And we need to get people in local

government concerned as well. Of course, with respect to the federal government and at the state level. So let me just tell you of the concern that I expressed decades ago to our Chief of Police, our Chief Public Safety Officer in the city of Irvine. We actually, in the wake of Fukushima, took a tour of San Onofre. Spent just about a whole day here looking at the situation, and we could see this is a serious problem. This is a very serious problem.

And in fact, how do we keep the people of the city of Irvine safe in the event of a nuclear accident. Here, with respect to the stored nuclear waste, how do we keep people safe? I asked that of the Chief of Police and he said, "Larry, we can't. We just can't. We would have even in Irvine, 25 miles away, we would have an unmanageable, uncontrollable situation that would be almost immediate panic as people understood what was going on. We can't do our jobs to keep the people safe. The only safe approach is preventing such a catastrophe". That's what we're all about, I think, right here. So let me. Let me just kind of review this theme again. So keeping people safe at the federal level, we know where that is. We're mired in plan after plan, patchwork plans of one kind or another. Inadequate plans of one kind or another. There is no national repository as there should be. There is, I guess, a search now for consolidated interim storage of nuclear waste. From afar, it appears to me they'll never get there at the federal level, not unless they're pushed tremendously. And how might they be pushed? Well by the people, presumably. But I'm thinking by the state of California as well. So what we need is a Cal safe nuclear storage waste plan. We need a safe nuclear waste storage plan. And I underscore ‘plan’ because if you were to ask people at the state of California, "well, what is our state plan? What is our state plan for keeping people safe?" We have no state plan.

**Vice Mayor Larry Agran:** None whatsoever. None that I'm aware of. What does that mean? I guess the state plan is let's hope the federal government does its job. Well, hope is not a plan. Hope is not a plan. So what I think I have to offer here is the fact that we're going to be introducing legislation for a safe nuclear waste storage plan where the legislature directs the Governor and his Office of Planning and Research to develop a plan. If this legislation were to pass it would direct the Office of Planning and Research to develop a plan over the course of one year and bring it back to the legislature. What would the configuration of the plan be? It would involve moving the nuclear waste stored as it is in this configuration, this extremely dangerous configuration. It would involve removing those canisters from those silos. Having a hot cell in a dry storage facility so they could be inspected. Repaired? Possibly. Repackaged, and then restored in a storage facility. It would be a fortified storage facility on higher ground. On higher ground, either at the mesa or other higher ground site. That would be the plan. That

would be the plan stored at Camp Pendleton that would provide us, if it were developed as a plan and executed successfully at least another 100 years of safe storage. That's the idea. Thank you.

**Stephanie Cooke:** Thank you. It's an extremely interesting idea. I bet there's a lot of questions. I'm going to allow 1 or 2 now, but at the end of the session we'll have an open time for all questions of all three speakers. So does anyone have a question off the bat, please?

**Audience Question:** Just just given the history of this site and the waste that's there, what gives you confidence that a plan could really be developed in one year? Not trying to discourage the idea of a plan, but that seems awfully optimistic.

**Vice Mayor Larry Agran:** Well, if I were Governor, here's how I'd do it. I'd say all right to develop a plan, it would probably cost half $1 million or $1 million to develop the plan, and I would bring in folks who have done this kind of thing around the world elsewhere, safely stored nuclear waste. And a year is ample time. A year is ample time. This is actually conceptually a pretty simple operation. Would there be problems of one kind or another? Of course. But it's not a complicated plan. Removal of the canisters as they exist now. Have them inspected, repaired, repackaged in a hot cell facility, and then moved to a more permanent storage facility. That's not a complicated plan. It may be very difficult to execute, but to put together a plan in one year. Are you kidding? Yeah, if there's the will to do it, it will be done.

**Stephanie Cooke:** Okay, great. Thank you. Well, I think that I'd like to introduce our next speaker, who may be able to amplify on this idea, because it sounds to me if it's if you're talking about Camp Pendleton, then there's negotiations involved with the military.

**Vice Mayor Larry Agran:** Let me just respond to that, if I might. People have said, "well, you know, the military, they kind of frown on this, they don't want that stuff moved." Who the hell is in charge of the military? It's the United States government civilian leadership. Yeah.

**Stephanie Cooke:** Well, I hope our next speaker, who you had a sneak preview of in the film we just saw, can address this as well. His name is Rear Admiral Len Hering. He is a prominent military and civilian sustainability leader with a broad background in both energy and environmental issues. You could see his passion on the film, but I'll reiterate he is obviously passionate about sustainability and educating people on the dangers the future holds without taking responsible actions to secure the energy independence of our country, but also to preserve water, air quality and other resources. So with that, I will introduce Admiral Len Herring. Thank you.

**Admiral Len Hering:** Okay, before we get started, what was interesting, I actually think the last time I wore this suit was in that presentation, my presentation to the Senate. So I want to thank the Samuel Lawrence Foundation for all of its efforts. Since we began this journey, they have been intimately involved in making sure that the citizens of San Diego and LA and the likes, 50 miles of the San Onofre area, are aware of what's happened. And more importantly the security issues that I believe, as I testified, have been sorely misrepresented. And more importantly, the citizens of the San Diego County and LA County area have been undermined so that they truly do not understand. And I just want to ask a quick question. How many representatives of mayoral staff are here in the 50 mile range? Any elected officials? Okay, as I understand by my googling, this should be held in about a 600 seat stadium. So the purpose of me being here and just so that, you know, a little background, I am not an expert in the field of nuclear energy, but I am an expert I do believe in its handling. I was a nuclear weapons safety officer, a nuclear weapons security officer, and a nuclear weapons handling officer. I had intimate knowledge and experience on how to handle the material and what it takes in order to do it safely. And I have handled thousands of pieces of ordnance.

**Admiral Len Hering:** I was on an AE which had the equivalent of a carrier's load of ammunition on board, and we moved it all the time. But I will also tell you that before doing so, we went through extensive training, testing and evaluation beyond your imagination, and no one was allowed to touch not even a piece of handling equipment until they had been fully certified. Well, when I got involved in this process, I found out that none of that exists in the commercial world. None of it. Even to find out that, as I said in my congressional presentation, that the equipment that you see, loading those canisters into the silos was approved on a piece of paper, not a prototype. There was not an opportunity for that particular piece of equipment to be tested to its Nth degree. The individuals who are responsible for moving that material, as I said, were hired through the company, mostly from Clark Construction. Why? Because they're familiar with the handling of construction material. We're not moving construction material. It's not a fork truck. These are canisters full of nuclear waste. And had it not been for the near miss that

occurred while loading that material, I would not be here today because it is that event that Congressman Mike Levin started this process. And had it not been for a OSHA inspector who, by the way, was not a nuclear qualified OSHA inspector, he was a commercial construction OSHA inspector who blew the whistle after the public meeting was near finished and the individuals responsible for informing the public and, more importantly, the NRC, that the incident had occurred.

**Admiral Len Hering:** So over the course of the last few years, I've been more and more involved with studying and experiencing what we see. And what I will tell you right now is that I am more convinced today that the NRC is nothing more than a waiver grantor for the commercial industry, for expedience and saving money, nothing more. There is significant experience in nuclear handling and issues here in this room alone who have gone for years asking simple and in some cases extremely complex and capable questions. I mean, you heard it in the brief. I mean, that individual has been asking the question since day one. And he was fired because he asked the questions. So what is it that we are doing? Well, I will tell you that San Onofre is the number one plant in the country with violations in its cause. More importantly, more waivers have been provided in the last five years to this particular company than any other company that has been dealing with nuclear waste and handling. Holtec is a contractor of SCE (Southern California Edison). So the whole program that is supposed to allow the local communities to engage is staffed by individuals selected by SCE. So when the experts in this room come to the CEP (Community Engagement Panel), they're afforded five minutes, 20 minutes total on a particular topic. And that is the end of it. And you will hear throughout the day individuals who have gone to the NRC and asked the questions, who still to this date, five years later, have not gotten a response, nor have they had the technical ability to discuss and resolve concerns and issues regarding anything in this particular scenario. So I'm here to tell you that what I am most concerned about is the fact that the citizens of San Diego and LA County are not being protected by the organization that is responsible for its protection. Imagine what would happen if the FAA did what the NRC is doing today in the handling of nuclear waste. Imagine what would happen. I wouldn't fly. I would have driven. I'd have left Florida three, four days ago, and I'd had driven across country. As it was, it was already a mess. But anyway, almost didn't make it. But the process, as we see it, is severely broken.

**Admiral Len Hering:** In the Navy because of our regulation and the constants of making sure that we are safe in doing what we do every day, when a regulation is written, it is expected to be upheld regardless of the mission requirement. And if a waiver is granted by authority, it is to make sure that that particular command understands that to the best of their very ability, that the regulation is in fact attained by a certain date, or you are considered not mission capable, and you must report so to the CNO.

**Admiral Len Hering:** You have no idea how many waivers have been granted in the last year to include a waiver which excludes them from talking to you, the community, in building emergency planning scenarios. So if you go to your emergency planners and ask them what the scenario is and what the plan looks like, as the Vice Mayor said, as the Chief of Police said, as the Fire Chief said, "it's not our responsibility." Excuse me. How many millions of people live within 50 miles here? One thing that I have the most concern over is that I'm constantly hearing "slim to none". Well, in the world of nuclear weapons, there is no such thing as slim. The programming, operation and planning for is none, and everything that we do is to make sure that none is even an exception, that it never happens. But if it does, we are fully trained to make sure that we know how to respond. Every single individual in the fleet knows exactly what to do if they're exposed or find themselves in a situation. The individuals at SONGS who came here got not one single moment of training. Should something have happened, that team would have been exposed to nuclear damage. Not one. And what's worst in the whole scenario is when the decommissioning occurs on a plant, the nuclear engineers disappear because it's no longer producing energy. So for the bulk of it, there are few engineers there, but it's not the same as when the plant is in operation. So the bulk of what's there are security personnel. It becomes a security matter, not a nuclear energy and protection matter. So again, the waivers are constant. They're over and over and over again. And the one that's probably the most concerning is that there's no monitoring. There is no monitoring in this entire scenario. And when you do find monitoring you will find out that they have just asked for a waiver to secure the inlet and the monitoring. And get this- the monitoring occurs on the inlet, but not on the outlet. So I'm not sure what it is that they're trying to prove by what's coming in other than the salinity of the air and the moisture has a major impact on the integrity of the canister, which is only approved for 17 years, and some of those canisters are almost six years old already, with no place to put them. And the president of the Holtec company admitting in public that they do not know how to download them, but they will address it when the time comes.

**Stephanie Cooke:** What do you mean by download?

**Admiral Len Hering:** In order for you to move the canister, inspect it, or if the canister is compromised, you have to remove the material from it and put it someplace else. Well, he admitted in public that they don't know what to do or how to do that yet, but they'll figure it out when they get there. And San Onofre is not the only nuclear plant that is infecting the decommissioned status, and that these particular canisters, 5/8 of an inch thick, are being used to store all this material. And when you go across the ocean and you see other places that have found solutions, they are significantly different and the

canisters are totally different. In some cases, they're 2.5in thick. So the 5/8 of an inch thick steel that is on yours is actually a little less thick than the chassis of your automobile to pass standard safety measures. So you have a whole lot of issues. I mean, there's so many of them it's not funny. And again, the NRC has failed to have a dialogue with the experts to make absolutely certain that the solutions are agreed upon. So what I'm here to do is tell you that if your elected officials are not more involved, we the people is what will suffer.

**Admiral Len Hering:** And everybody says, "well, the federal government is in charge here." I hate to say this, but as an individual, a graduate of the Naval War College and a study of the Constitution, the States' Constitution requires that it impose upon the federal government the demands that include safety of its citizens. And if these are not taken care of, the safety of its citizens are being compromised by the potential. I'm a meteorologist and oceanographer by degree so I get it. All you need is one king tide in earthquake bay that potentially brings upon you a tsunami equal to 1886. And SONGS is under 30ft of sea water, full of sand, full of debris, in which there is no capacity to clear, which means the cooling element of that canister is 100% compromised, and you have no idea what will happen when 72 of these things react in that fashion. That's what you have to deal with.

**Stephanie Cooke:** Thank you. That was a very powerful speech. The feeling I get listening to you is that the citizenry is asleep, because they're not being made aware of it. I talked to somebody on the plane yesterday who lives here. I said, "do you know about SONGS?" She said, "oh, no, no, I've not really heard anything about it in years." So what's the answer to that? How do you get the public more involved and demanding action?

**Admiral Len Hering:** Well, again, we the people and those who are elected officials, need to get with their counterparts and make something happen. I don't want to be the guy who says it's going to happen, that's not, and I want everybody else in the room to know I am a nuclear proponent. I come from a world in which all of our principal ships are powered by nuclear energy, but we're in 9th and 10th generation nuclear reactors. We are not dealing with this stuff. So it's a totally different story, but I am not an advocate for the continuation of this practice until the waste problem is taken care of. There should not be another one until we figure out what to do with this. And I honestly believe that it is the responsibility of we the people to stand up in the 48 states who are affected and start demanding that the federal government be held responsible by each of those respective states and their elected leaders until this problem is solved. The plan is a great idea. But until 6.5 million people all demand somebody

stand up and make this happen, this will continue because the rest of the citizens here will think that it's not an issue. And for those of you who are in the press, if you don't make this front page news on a regular basis, every time the CEP meets and the issues at the CEP are not addressed properly, you need to be more critical of what's happening here, and SCE and the NRC cannot continue to get away with the things that they are getting away with in answering the questions and concerns of those individuals who were potentially impacted by an issue or an accident that occurs here at San Onofre.

**Stephanie Cooke:** Yeah. Are there any other questions?

**Audience Question:** (Audience question)

**Admiral Len Hering:** The question is, because the Navy is what it is, why would we not subcontract to the Navy? First of all, it's not within the charter of the Department of Defense. So we are not budgeted for or the likes. The Department of Energy is our repository in the decommissioning process. So when the Navy decommissions its nuclear energy, it turns it over to the Department of Energy and they dispose of the material. The difference is that the material is different and the quantity is significantly different, and how it's handled is significantly different. We are not prepped, nor are we capable of handling or taking care of a repository that is of this nature. It doesn't mean we don't have the experience, but the Department of Defense is not chartered to do the work of the Department of Energy and the NRC. They have their own charter and that is their responsibility. I think the biggest problem that we have is the NRC has not established, which is what Congressman Levin is trying to do, establish a branch of experts that deal specifically with the decommissioning material and the decommissioning of the plant. The NRC does not have the expertise to do that.

**Audience Question:** Is the government capable of emergency procedures?

**Admiral Len Hering:** Sure. Absolutely. And the Department of Defense would be called upon if that be the case. But again, it's not the charter on a regular basis. The federal government needs to figure out how to solve the problem.

**Stephanie Cooke:** I'd like to introduce the Honorable Greg Jaczko, who was chairman of the US Nuclear Regulatory Commission. He was named by President Barack Obama in 2009, and he was first sworn in in 2005 and he resigned in 2012. He has been very controversial, but also right in the forefront of pushing the NRC to be more active and more conscious of safety. He was one of the good ones. He focused on safety of existing reactors and radioactive materials and implementing a predictable safety review process and ensuring the agency conducted thorough environmental reviews, and he pushed for strong enforcement and accountability. Unfortunately, there aren't enough like him at the agency. And so now he's focused on the work at SONGS and is with Rear Admiral Herring, a co-chair of the San Onofre task force.

**Dr. Gregory Jaczko:** I want to thank the Samuel Lawrence Foundation in particular for inviting me here. Bart was persistent in getting me to come out, and I'm glad that I did. This is great to see so many people here engaged on an issue that is critically important. I was making notes as I was listening to everyone because I had some ideas about what I was going to talk about. And it turns out, I think what I was going to talk about meshes perfectly with what you heard before. And it's really, I think, to get at kind of the why to some extent where we are here and, mobilizing all of you to get engaged. And I've been around this industry in this regulatory space and these policy issues for a long time, and I think what I find interesting is, we are here and we are in a place that is frustrating for so many people. And I was trying to understand why. And I wish, quite frankly, what I'm going to talk about today I had thought about 15 years ago, because when I was at the NRC, what I used to talk a lot about was complacency. And we have to make sure that as a regulator, that we're focusing on not having the industry become complacent because nuclear power plants are largely operating without accidents, so you get a sense that everything is going to be fine. Storage was happening, no major accidents. So everything is going to be fine.

**Dr. Gregory Jaczko:** And then, of course, when I was at the NRC, the Fukushima accident happened and that immediately damaged that concept of complacency. All of a sudden now we were faced with a real accident in a developed nation with a developed nuclear program using US designed technology. It was no longer easily dismissed as the Chernobyl accident was as something happening behind the Iron Curtain in a technology that was very different. So the thread that I think really exists with so much of this is really the issue of accountability and really what I think underpins a lot of what's happening and why we are where we are today, is the federal level lack of accountability for the nuclear power industry that the federal government has created with various laws, and with the way that it approaches problems. And so I want to go through that and talk about why I think that is and how we address that.

**Dr. Gregory Jaczko:** Because I think so many of the things that you heard from, from Len, from Larry, they really get to that fact that we've created this federal system that prevents any accountability for the nuclear power industry. So I think without a doubt, nuclear power and spent nuclear fuel, nuclear waste, these are some of the most intractable public policy, environmental and technological problems that we deal with as a country. And I think there's a few characteristics of that technology that lend itself to this culture of no accountability. One, most often the accidents are low probability. We have approximately 90 nuclear reactors operating in this country. Most of them don't have accidents. So it's almost always a hypothetical. So it's easy to dismiss that. It's easy to say, "okay, this is not going to happen in my neighborhood because it doesn't happen." So it's hypothetical. It's a low probability, but when it does, it can be very consequential. And similarly with nuclear, spent nuclear fuel, the kinds of incidents that are more likely are kind of chronic leaks over time, which will, you know, again, manifest not everywhere, but in a lot of places. So that makes it easy to avoid accountability, because the kinds of challenges you're talking about can be more easily dismissed.

**Dr. Gregory Jaczko:** I think it's important to keep that in mind as we talk about that. And that's why, we see today a nuclear power plant that's built on the coast, which is built that way for a reason, because intake cooling water is easy when you're on the ocean. That was the reason, decades ago when that was done. Of course, because you have a plant there over time, when that plant eventually is done and you have the waste, the waste goes right there, right? It just kind of follows through because there's no real sense of accountability throughout for that waste and what's really happening. One other scene setter that I want to mention is, of course, climate change. And I think Mark Jacobson's here. So I'm sure people are going to talk about this with more expertise than I can. But, nuclear today is very prominent because of concerns about climate change. And many, many people are trying desperately to come up with solutions for that and believe that nuclear is. In many ways it is simply not the right solution, but it has captured the kind of imagination of federal policy makers, of the finance community, of the kind of think tank community in a way that, again, lends one to want to support a culture of no accountability.

**Dr. Gregory Jaczko:** We can look away from the challenges of nuclear power because we need it for climate change. So I think those factors are all at play. As I talk about this idea of the culture of accountability, I think there's historical basis for it. If you look ultimately for the existence of the nuclear power industry in this country, it is a genesis from the nuclear weapons industry. It was the Atomic Energy Commission that was established to develop nuclear weapons that then led to this technology, the potential proliferation of nuclear weapons throughout the world, and the need to try and divert that technology into uses that were not weapons related. And that is why we have today a nuclear power

sector, that entity, that government entity, which was one of the most powerful government entities ever created, operated with almost no accountability itself to the usual levers of authority and power. It did an amazing job with the task it was presented, but I think also created that culture, which then flowed through ultimately to the need to create the Nuclear Regulatory Commission to actually just have as its responsibility safety and security.

**Dr. Gregory Jaczko:** Originally, those responsibilities were vested within one organization. And I think, as the industry then started to develop, you had a need. The government had a need to push that industry for non-proliferation concerns and weapons related issues. And one of the first concerns that came up, of course, was the fact that you had the likelihood of accidents. And I think this is one of the first what I would call, the official codification of this culture of no accountability was the creation of the Price Anderson Act. And for those of you who aren't vested in the arcana of nuclear power policy, the Price Anderson Act is the reason that you will never have a homeowner's insurance policy that has a rider for radioactive waste incidents. You cannot get it for an insurance policy. Okay, so if you live near a nuclear power plant, you can't get an extra rider to protect your house in the event of an accident, because there is a federal law that indemnifies all nuclear power plants against third party liability for accidents. That law also places some responsibility on nuclear power plant owners to provide a certain amount of insurance coverage, but it is not the amount that would be likely in the event of a severe accident. So you immediately take away one of the most important and significant factors for accountability for the nuclear power sector by saying you are not responsible for accidents.

**Dr. Gregory Jaczko:** I think that culture then pervades through the way that the federal government has always treated this technology. When I was at the Nuclear Regulatory Commission, it was at the height of what was then called the nuclear renaissance, a term the industry used as they attempted to reinstate the idea of constructing and building new nuclear reactors. There was a significant government push to help and support that which one could argue that's the role and the job of the government to support and promote energy technologies. We do it in lots of different sectors. As Len is a strong supporter of nuclear power, I personally am not. But one can have a very reasonable argument about whether the federal government should do that. But where the culture of accountability came in is that in that first wave, and this was in the late 2000s, when significant effort to spend federal resources, taxpayer dollars and create policy initiatives to bolster a new wave of nuclear reactors. Almost nothing came out of that, and we were talking about billions and billions of dollars being spent. Now the government makes mistakes. That happens. That's not necessarily the point. The point is there was no accountability for that.

**Dr. Gregory Jaczko:** There were no congressional hearings bringing the heads of these power companies that took hundreds of millions of dollars from the federal government to develop new technologies. There were no hearings held to bring forward the heads of one of the companies that was building one of these new reactors, who was indicted on federal false information charges. So there were no hearings on that. There was no accountability. And that just continues to foster this culture of no accountability within the sector. So where does that leave us today? Well, here we are again. I think, as Stephanie mentioned, not only are we not trying to impose more accountability, but we are going the other way, which is trying to put even more pressure on the Nuclear Regulatory Commission, which is one of the few entities that has accountability for safety over the nuclear sector and weakened that entity. So, again, it reinforces this idea that the federal government's view is that nuclear technology is a technology that can operate without accountability. And, you know, this is a waste, radioactive waste discussion. Well, here is probably the area in which there has been probably besides Price Anderson, the greatest institutionalized lack of accountability by the federal government, deciding that the federal government would be responsible for building a waste storage facility for the waste that is produced by nuclear power plants.

**Dr. Gregory Jaczko:** Now, I don't know any other public sector in which you have hazardous material production, in which the federal government has decided that it will be responsible for building the facilities to host or hold the waste from that industry. I don't think it exists in the chemical industry. I don't think it exists in any other industry. So what does that tell the nuclear power industry? We don't have to worry about our waste. We don't have to worry about the liability if there's an accident with that waste. And of course, then there is no accountability. So there's no need to be responsive to community interests or community concerns about what happens with that waste, because ultimately those companies don't have accountability. And you can look no further than as I said, this massive subsidy effort in the 2010s to build reactors, the one data point you could look at for success from that, I use the term success loosely, was the construction of a nuclear power plant in Georgia. Vogtle three and four. Those plants were built. They were $15 billion over budget, seven years late. And what happened to the CEO of that company? Well, he retired when they were finished. What happened to the stock price during that period? And you can look up the numbers exactly, but it did not go down. So it was Southern Company, which is a publicly traded investor owned utility. Its stock price went up dramatically. Why? Because they operated in a system, a utility system in which there was no accountability for the nuclear power plant operators because the costs of that plant are borne by ratepayers. Those ratepayers are ultimately represented by a public service commission that was largely, an elected in the state of Georgia. And those elections were largely heavily influenced by the utilities in that state. So even there

at that state level, you have no accountability for what would, in almost every other sector of a private company, be grounds for dismissing a CEO, for having hearings, for having lots of focus on the failures. And we don't see that.

**Dr. Gregory Jaczko:** So what do we do about that? I teach public policy at Princeton and I advise seniors on their public policy theses. And the one thing I always tell them is when you come up with recommendations for policy, don't do a list of shoulds. But, I'm going to do a list of shoulds. That's kind of the poorest policy solution to say, "we should do this, we should do that." Well, if we could just do this or do that, it would be easy. But I just want to plant the seeds. I think it meshes with what both Len and Larry have said, but I think it takes it a step further. If we're going to talk about how you can engage and begin to engage elected officials, this is, I think, the kind of messaging we need to think about and start talking about. Number one, the federal government has to recognize that it can no longer create this culture of no accountability. And one of the first ways, of course, it could do that, and this will be probably the hardest thing, is to eliminate the Price Anderson act, allow the nuclear industry to make those calculations about risk in the way that almost every other company does. Boeing does not have federal indemnification protection against accidents. No other industry has that except the nuclear industry. So you either need to phase that out, or eliminate it, but phase it down is perhaps a more meaningful way to do it.

**Dr. Gregory Jaczko:** The second immediate solution is that the federal government needs to recognize it is not the federal government's job to find a repository for nuclear waste. It is the federal government's job to make sure that the industry practices safely, that it does what it's supposed to do, that it doesn't break the law, but it is ultimately the responsibility of the entities that created that waste to find solutions for that waste. There is no reason we have grown into a culture of thinking that this is somehow a problem that the federal government has to solve. If we look at almost every other high tech industry in this country, the movement is more towards private sector development. Look at the space industry, right? You know, I grew up as a kid thinking NASA, that the government was the only one who could do space exploration. Today, we have turned that over to the private sector with some amazing results. The federal government needs to get out of the business of geologic repositories. It is the responsibility of Edison to find a solution for its nuclear waste. It is not the federal government's responsibility, and I quite frankly believe that if the federal government tomorrow said we're done with this, we would have solutions faster than you could imagine, because now Edison can no longer sit back at shareholder meetings and say, it's not our problem.

**Dr. Gregory Jaczko:** And as long as they can do that, they're shielded from accountability. It's not our problem. It is the federal government's responsibility. And that is, I think, one of the key things that the federal government can do. And then of course, I think as Len touched on this, it's to reverse its approach to the Nuclear Regulatory Commission and encourage the Nuclear Regulatory Commission to be a stronger regulator, because it is ultimately how you can establish that accountability. And as we've seen, I might quibble a little bit with Len about the FAA, but we've seen, for instance, with Boeing, with the incidents that have happened with the 737 Max, accountability happened immediately and as unfortunate the tragedies that happened with the accidents with other issues, and as a regulator, I look at that and part of the underlying problem was, again, a weakening of the FAA's approach to oversight and safety. But the accountability was there. Boeing has been under criminal indictment, Boeing has civil liability, and they at least have been in front of Congress and have fired their CEO. They've at least made a public acknowledgment that they have to change. We don't see that in the nuclear sector. The CEO of Southern, when Vogtle was massively overrun, was fetid when he finally ended his time as the CEO of Southern. So there is just that difference in culture. So, you know, I think those are the kinds of things that are ultimately going to get you to a place in which you no longer have nuclear waste sited 100ft from the ocean in a location that it really has no business being in. But it is there because the people who produced the waste generated a profit from it, were very successful at that, and did it in a rate-captured environment in which they could present a nice return for shareholders. They're not responsible for it. And if you can change that, believe me, that fuel will move because this is not the place that they would leave it if they actually had accountability for it. So I will end at that point.

**Stephanie Cooke:** This was an excellent presentation. I would almost say heretical suggestions. I want to point out something historically that when the first hearings were held that led to Price Anderson in the 50s, companies like GE said they would simply not build reactors if they had any liability. And that stemmed from their military involvement during World War II and the bomb project because they said, okay, we'll do this, but we want no responsibility if things go wrong. They said they could not quantify the risk. So that would be an interesting dynamic what you suggest, if you said throw it over to the private sector, see what happens to the private sector and nuclear. Right now their hands get held by the US government and everybody's asleep at the wheel. And I think it's time for everyone to grow up. I think this is a very, very interesting suggestion, and I'm going to stop my comments and ask for comments from the audience or questions.

**Audience Question:** Thank you. There have been several lawsuits against Southern California Edison. The company had to pay a significant amount of money to attorneys for sure and to implement certain

procedures. My question is is anybody pursuing that kind of legal action on a greater scale? What you are talking about is just a clear violation of human rights and probably many state and federal laws. So that could be that could open, those people sitting on their hands to litigation. So it is just a matter of successful litigation. Could be. Are you aware of any litigation in progress or would you support such efforts?

**Vice Mayor Larry Agran:** Litigation, in my judgment, it would be of a significant symbolic effect, but it would have no practical success in the near term. Having heard from Len and from Greg, let me just say that yes to accountability. We have an urgent situation here with respect to San Onofre. Institutional reform and accountability. I'm all for it. But I don't know how we get it other than having the state of California on our side in the forefront. In my judgment, politically, when we introduce our legislation, it's going to be with, I hope, the entire delegations of Orange County and northern San Diego County. We need a real solid front here at the Southern California level. We're talking about the decimation of the entirety of Southern California. It's hard to wrap your head around that, but we need a political response, which is not only the introduction of this legislation. You know, there's going to be a campaign for Governor in a couple of years, and I can't imagine a better issue for a candidate for governor from Southern California to make this the number one priority issue for the next Governor of California. If we can't get the current Governor to move off his butt and do something about this.

**Admiral Len Hering:** And just one point about litigation since I've been involved in this entire thing, and Greg and I have watched some of these happen, as far as I know, I think there have been three lawsuits that were brought against this entire effort. They were settled in court. None of us know the results of the outcome, because they were restricted from telling us how they had been paid off, basically paid off to solve the problem. So I think a problem is because I think Greg's solution is what it is, is that those individuals do not have the capacity because the federal government has the authority. And it's harder for you to tell the federal government how to react when it is mandated by law to do so. So what needs to happen is, I think and you're right, Larry, if the state of California stood up and said, I believe you, but per my Constitution, I afford you the opportunity to defend my people in your decision. And then the story becomes something totally different. I mean, you've got the engineer from the Coastal Commission right here, and the Coastal Commission determined that it did not have the opportunity to tell the federal government whether or not this was safe, because their regulation capacity from the state only included those lands that were theirs, and that therefore, the Coastal Commission, which we all thought could have had an opportunity to slow things down and progress in a different fashion because of the legalities of the law, were forced to say, there's nothing else we can do about it. So it is that piece that is

necessary for the state to rise up and say, you're not doing what we think is right for the people of California.

## Panel One: Clear and Present Dangers of Radiation

**Alison St. John:** In some ways, what Larry told us is a sort of a beginning of a shift in the stuckness of this situation. And so I'm very excited that he was able to make that announcement here today about getting the state involved and whether it works.

**Alison St. John:** I would like all three of the next panelists to come up, if you would. That's Mark Jacobson, Deanna Polk, Leona Morgan. And this panel is titled, "Clear and Present Dangers of Radiation". So all of these panelists have studied, lobbied, worked, researched, written about the dangers of the nuclear industry. Let me start with Mark Jacobson, who is Professor of Civil and Environmental Engineering at Stanford University and the Director of the Atmosphere Energy program at Stanford. His work focuses on how to develop large scale, clean, renewable energy to face the challenge of global warming and air pollution, and his recent book, *No Miracles Needed*, I can highly recommend it addresses the question of whether it's possible to replace fossil fuels and dirty energy with sustainable energy technologies, and he makes a very strong argument that it is possible. So it's a very encouraging read in a time like this, when it seems like there's so few solutions and everything looks so dire, it's very encouraging to read Mark's book.

**Alison St. John:** Let me just tell you who everybody else is. We have, Leona Morgan, who is joining us from New Mexico, is an indigenous community activist who's fighting to stop uranium mining near the Grand Canyon and force companies to clean up the toxic effects of decades of uranium mining on Navajo land. And so she's intimately familiar with both the front and the back end of the nuclear industry, because not only has uranium, which is used to fuel nuclear power plants, been mined on her lands, on their lands, there's also an effort to consolidate interim storage, to locate consolidated interim storage of radioactive waste, which we talked, we heard briefly about from Larry in the last panel on their land. And we'll hear what she has to say about that. Then we've got Deanna Polk in the middle here, who is a nurse who specializes in radiation oncology, who's been deeply involved in emergency response training. She was a member of the Disaster Response Team at Scripps La Jolla. She was the Emergency Preparedness Response Coordinator for the Council of Community Clinics, and she has testified at federal hearings and posed some very difficult questions to nuclear industry professionals about how to prepare for a nuclear emergency. So that's what we have in store for this panel. So I'd like to start here with Mark.

**Dr. Mark Z. Jacobson:** Well, thank you very much for your kind introduction. So I'm going to talk about why we do not need nuclear power, either existing nuclear or new nuclear, small or large reactors. But I want to show you what we do have and what we can have. And also I'm going to explain why new reactors are not helpful at all for addressing climate, air pollution or energy security. So I look at computer modeling of air pollution, climate and renewable energy solutions to these problems and have for now for 35 years. And I try to address three problems: air pollution, which kills almost 7.5 million people each year worldwide, including about 12,000 California; global warming, which will only approach the cost of air pollution which is right now on the order of $30 trillion per year based on statistical cost of life and morbidity by 2050; and energy security, which of course there are many types of energy security, but one of them is just the fact that fossil fuels are limited resources, they will run out at some point and that will cause economic, social and political instability. The solution I want to talk about really briefly before we get into why is nuclear not helpful, is really to electrify everything or almost everything.

**Dr. Mark Z. Jacobson:** There are four major sectors: electricity, transportation, buildings, and industry. And for transportation we go to battery electric vehicles, hydrogen fuel cell for long distance heavy transport. For buildings where you get rid of gas, go to electric heat pumps, electric induction cooktops and we would not need gas at all for any process. We go to energy efficiency LED lights. For industry we go to electric arc furnaces, induction furnaces, resistance furnaces. They produce high temperatures for industrial processes. They all run on electricity, all these technologies. And we provide the electricity with just wind, onshore and offshore wind, solar photovoltaics on rooftops and power plants, concentrated solar, some geothermal electricity and hydroelectricity, maybe tidal and wave power. There'll be some small amounts of geothermal and solar heat as well. We need storage like electricity storage, heat storage, cold storage, hydrogen storage. We have the biggest type of storage worldwide is conventional hydropower, followed by pumped hydropower. Batteries are growing. As I'll show some results for California, we have a huge amount of batteries on the grid in California already, actually more than a third of their normal average power demand can be supplied by batteries for four hours now.

**Dr. Mark Z. Jacobson:** Anyway, there are other technologies for heat and cold, there's water tank ice, underground storage and boreholes, water pits, aquifers, firebricks for industry. These are high temperature bricks you can store to heat up to 2000 degrees, only 1% loss per day. So when you have intermittent renewable energy, you can provide excess renewable energy like we have in California. During the spring we've had 98 days of 100 over 100% renewables in the state. Use the excess electricity,

dump it into firebricks, and then you can provide 24 hours a day, seven days a week for heat for industrial processes. Which, by the way, industry results in about 17% of global carbon dioxide emissions just from the heat needed and another 8% due to the chemical reactions.

**Dr. Mark Z. Jacobson:** So what's wrong with nuclear as part of the solution? Well, let's talk about new nuclear. Every reactor in history has taken at least ten years between planning and operation of a new plant, and now they're taking 22 years. I'll actually give you some times in the next slide versus six months for rooftop solar. You can get from planning to operation now and 1 to 3 years typically for utility scale solar and photovoltaic and solar and wind. Just to put this in perspective, China this year is going to build 340GW of solar and wind. That's 6.5GW a week, or almost one gigawatt a day. That's one nuclear reactor peak power a day of solar and wind is being produced in China. And for comparison, over ten years they're proposing to build like 25GW of nuclear. But in fact, last year and the year before, they built 1.2GW. And so the ratio of what's actually being built, the solar and wind to nuclear is 272 to 1. That's the ratio of what's actually being built in China. And China is building nuclear the fastest of any country in the world. So it's not helping. In fact, the output of nuclear in 2023 worldwide was less than in 2004. So nuclear is not growing worldwide. It is declining. There's more retirements than what's growing. Reactors take now in North America and Europe, 17 to 22 years between planning and operation. We need to solve 80% of the climate problem by 2030. And you can't do that if a technology is not going to be available, if you've started today, until 2041. So even regardless of cost or any other issue, there's the time lag between planning and operation makes it impossible. And small modular reactors are no better because they're not even planned to have prototypes until 2030, 2031. And they have all the same problems as large reactors. On top of that, capital costs like Vogtle in Georgia, the only pair of reactors built in 30 years, cost $35 billion for 2.2 or 3GW. That was almost $16 a watt, new Solar is $.8 a watt. So we're talking at least 16 times the capital cost, but the levelized cost of energy accounting for the higher capacity factor of nuclear and other factors is still going to be 5 to 8 times the cost per unit energy as wind and solar. So you're going to be waiting around 15 more years for something that costs 5 to 8 times more. That's an opportunity cost.

**Dr. Mark Z. Jacobson:** Plus it's not carbon free as claimed. It's 9 to 37 times the CO2 emissions. Just to give you an example, I mean, half of that compared with wind, half the opportunity cost emissions of nuclear is the fact that it takes so long and you're burning coal and gas and oil and biofuels in the background. So all those emissions count. And on top of that, you have all these construction emissions, like Vogtle, which took 17 and 18 years respectively for the reactors. It had enough cement to lay a

sidewalk between Miami and Seattle. So all that CO2 emissions already gone into the air and a lot of other emissions just from constructing that reactor that won't pay itself off.

**Dr. Mark Z. Jacobson:** And also on top of that, the opportunity cost emissions would be lucky in 20 years if it breaks even in terms of carbon. So it's not carbon free. It also has heat emissions because it's hot. Nuclear reactors are hot. They release heat, they release water vapor. You know, it's not a large amount, but between the two of them, it's about five grams of CO2 per kilowatt hour, which is, by the way, what IPCC (Intergovernmental Panel on Climate Change) claims is there, the life cycle CO2 emissions is around thy claim like six, whereas real studies the range is from 6 to 110. So really the average is like 50. And so people who are claiming nuclear is good use a life cycle emissions of six grams of CO2 per kilowatt hour. That's almost just the water vapor and heat emissions from the reactor in which they don't even account for. And they don't account for the opportunity cost emissions, they don't account for the land use change emissions, and they also exaggerate in a low direction the life cycle emissions of CO2. The IPCC does say, with robust evidence and high agreement, that increased use of nuclear leads to more weapons proliferation risk, meltdown risk, waste risk and mining risks. So these are all the issues with nuclear. So it's not a solution. You just can't even build it regardless of all these risks.

**Dr. Mark Z. Jacobson:** Just to give you an example, here are some plant operation times of real reactors. Olkilouto in Finland, 22 years on the left is construction time, but we're looking at plant operation 22 years. Hinkley is expected to be 18 to 19 years. And that's not even certain. Actually, no. So sorry. This is old Hinkley is now 21 years estimated, they've pushed it off till 2031 or 2032. Vogtle took 17/18. Flamanville is 20 years, which it's not actually open yet, so it might be longer. Even in China there are 12 to 14 years. In UAE they were all for reactors 12 to 15 years. Now I just want to show you this is why we don't need nuclear and why it's not useful in California, why Diablo Canyon is completely useless going forward and should be shut down. From March 7th through June 30th this year, which is 116 days, for 98 of those days California was over 100% renewables on its main grid. California is the fifth largest economy in the world and has been over 100% renewable for an average of 4.5 hours a day over the whole entire 116 days, over 100% renewables.

**Dr. Mark Z. Jacobson:** Here's just one example that I want to show because this is a day with an eclipse. (Referencing slides) Here's where the eclipse is this is the supply. Well, both of these show the same thing. This is the percentage. And that's the absolute amounts. This is 100% demand. And that's the actual demand the red. But here's where the eclipse occurred where the solar yellow is solar output.

Green is the wind. This light blue is hydropower. And then there's geothermal and small hydro and the dark blue is batteries. So solar output went out, went down, batteries kicked in to fill the gaps. And these are batteries going in at night. But you can see that on the right, the absolute amount the demand actually jumped. Anybody know why demand went up during the eclipse. Well because it's because 12.5% of California's electricity is supplied by rooftop solar. And which is not grid doesn't go on the grid. It's just used to reduce your own use. And so people need less demand. So when there was an eclipse there was less solar available. So demand for grid electricity jumped. So grid electricity jumped. Utility scale solar, which is the yellow, went down because there's less supply. But you can see how. The good news is, the reason you get this dip during the day instead of it just going straight is rooftop solar is crushing, is killing the demand, which is good. It's getting rid of the demand for electricity which is why we want rooftop solar.

**Dr. Mark Z. Jacobson:** Like last year, we changed the net metering law in California so that it killed the solar, the rooftop solar industry. Basically, initially, 90% of the solar went down, but now it's down to like 40% or 50% lower than it was last year. And whereas we need more rooftop solar, especially because we're going to electrify more things. But just to show you, this was a day where we reached 162% of demand on the grid, and that was on May 5th. And so you can see that the rooftop solar, though, that caused the demand to drop during the day. I'll just show you a couple other days. This is a day where we met 82.3% of demand over the 24 hour period. Day and night. And so the goal is to fill in those white spaces. And I'll show you how we can do that. This is where Diablo Canyon comes in. This is another day. This is the maximum peak battery output. So we now have eight gigawatts of batteries on the Caiso grid in California. Caiso is about 82% of California's grid. If you add the rest, plus the batteries of people's homes, which are not included here, we're talking, on the order of like 12GW of batteries. The average demand during all seasons except summer in California is like 22GW.

**Dr. Mark Z. Jacobson:** So right now in California's grid, we have eight gigawatts out of 22. That's more than a third of the demand of the average. Demand can be met by batteries, which is amazing. And that's doubled in one year. It's back to 105% higher than last year at the same time. So that blue is filling in, getting rid of gas. Anyone want to guess how much less gas output there was this year compared to last year for this whole three month period? It's 40% less gas output. That's because utility solar rose 30% in one year, 31%. Wind rose 10%, Batteries rose 105%. Gas went down 40% in one year. That's how you solve the problem. Nuclear, you can't build it. It's too expensive. You can't implement it. And now it's a hindrance in California to solving the rest of this problem.

**Dr. Mark Z. Jacobson:** This is the record so far 19.4GW of solar. So there are 22 days in the last three months where solar alone exceeded 100% of demand on California's grid. This is not one, but this was the peak output, 19.4GW, and also the maximum daily output 208GW on the grid, so that the area is the largest ever in California. And this just shows the sequence of every single day during the 119 day period, where here's 100% of demand this line right here, and you can see all those days, there are 55 days in a row, 98 out of 116 days, where we're over 100% renewables. This is the average number of hours per day that were over 100% renewables. The maximum was 10.2 hours, I think.

**Dr. Mark Z. Jacobson:** But this shows every day the daily amount of wind, water, solar. You can see how it's approached up to 82%. This just shows a comparison of 23 versus 24. Just really quickly demand has gone down a little bit even though it was hotter in 24. Demand went down a little bit because of more rooftop solar. Solar went up 13%. Wind went up 10%. But geothermal, small hydro and large hydro declined. Batteries went up 105%. Gas went down 40%.

**Dr. Mark Z. Jacobson:** So you can see in one year how the demand dropped on the grid. So this is the last slide I'll talk about. So what is needed? Well more utility PV and batteries, more rooftop PV and batteries, heat pumps, energy efficient buildings, offshore wind. That's because offshore wind in California peaks during summer. And right now in summer, we're not meeting 100% because the air conditioning demand has just skyrocketed. Offshore wind peaks in the summer and in the late afternoons, early evenings. But where's the biggest transmission line to the coast in California? It's the Diablo Canyon. It's like a 3.3GW transmission line and Diablo is like 2.2GW. So it's hogging that transmission line and it's preventing the faster growth of offshore wind off the central coast of California. And so this is really what we need. This is the biggest, easiest source. So we're going to put a lot of utility PV and rooftop PV. Shifting more hydro to night, which will help and using demand response to shift through time that people use electricity is also effective. But anyway, we can solve the problem with just these techniques.

**Dr. Mark Z. Jacobson:** I'll just show this one slide just to show this is offshore wind in California. These are from data. Here's all the other seasons. Here's summer. This is wind speed off the coast in Mendocino, which is the fastest location of winds in California. Cape Mendocino, Northern California. It's like two meters a second faster in summer than all the other seasons. And wind power is proportional to the cube of the wind speed. So you can imagine the power output in the summer is way higher in California offshore than any other season, and it also peaks later. There's a peak late in the afternoon,

early evening here in the evening as well. So that's really how you solve California's energy needs is with those techniques. But Diablo Canyon is supposed to be subsidized for $12 billion. You can use that $12 billion and replace it one and a half times over. And that's just the subsidy that's on top of its normal cost. That's the additional subsidy that's going to be paid. Federal government is paying like 1.5 billion. But PG&E is the one who estimates $12 billion to subsidize Diablo for a few more years. So it's just ridiculous to keep that open. I would just urge you to advise people not to keep Diablo Canyon open. Thank you.

**Alison St. John:** I mean, it sounds like the nuclear industry has its foot in the door and in the powerhouses of power. And the sustainable energy that you're saying could work, just don't have a foothold yet. Yeah. So who has a question?

**Audience:** (Audience Question)

**Alison St. John:** So the question is, is there any chance of making the closure of Diablo? Is there a chance that we could get Diablo closed? What's your take on that?

**Dr. Mark Z. Jacobson:** I mean, I can't say very well, but I know the federal government has offered them money, and that's why like one 1.5 billion. And that's why Gavin Newsom accepted it. Because Diablo Canyon was supposed to close, but because the federal government offered money, they kept it open. And now there have been challenges to keeping it open, but they've all kind of failed. But I think there are still some alive. I think it's going to be difficult unless the state really realizes and the politicians realize that this is not helpful at all. And if the money if the subsidies do, because PG&E said they were going to be up to $12 billion. And so that's going to come from California taxpayers. California already has the second highest electricity rates in the US after Hawaii, which had amazingly high rates. Now we have almost Hawaii's rates up to $0.60 a kilowatt hour in PG&E's district during the afternoons. And I think those subsidies they've acknowledged that they're going to cause the rates to go up even higher. So there may be pushback, but I don't know for sure.

**Alison St. John:** Thank you. So, there's probably a lot of other questions. We can take one more.

**Audience:** Well, my question was, rooftop solar. It seems like Governor Newsom has killed that. Why is that? And also, if you look at J.D. Vance, you know, on the other side, God forbid if those guys win. What is your reaction to them subsidizing nuclear? First, Governor Newsom, new rooftop solar, next nuclear in a new Republican administration.

**Dr. Mark Z. Jacobson:** Well, the reason that the NEM requirements were changed was that there were these claims last year and the year before that, that the previous NEM was subsidizing rooftop solar owners, which tended to be more wealthy people and that therefore poor people were being disadvantaged. But that was based on wrong information and I don't want to name names, but they came out of Berkeley. NRDC supported this, too and they were pushed by the utilities. Utilities were pushing this narrative. And the narrative was that, well, electricity demand is going to be constant. And rooftop solar is reducing the demand. As you can see, their rooftop solar does reduce demand. And they're saying, well, the remaining demand, you're going to have to spend the same. The rates are having to go up proportionally to everybody else, because the demand is going down. But the false narrative there is that rooftop demand will not stay constant. It's going to increase, sorry, electricity demand will not go down in the future. It'll increase because we're going to be electrifying more transportation. We're going to be electrifying industry. We're going to be electrifying buildings.

**Dr. Mark Z. Jacobson:** And that's going to basically double overall electricity demand in the next 15, 20 years. And so we're talking even if rooftop solar took a quarter of that, that's still going to increase the need for more electricity on the grid by utilities. And that will actually reduce the rates of rooftop owners. But the other thing is they're completely ignoring the fact that when you have rooftop solar, that's reducing your energy needs because it keeps your house cool. Solar itself actually absorbs 20% of the sunlight, reducing electricity demand in the summer. It also reduces wildfire risk because we don't need as much transmission line. Fewer transmission line sparks. And that's why we have high utility rates in California. It's not because of renewables. It's because utilities are passing on the cost of transmission line sparks that cause wildfires, passing on the cost of the San Bruno and Aliso Canyon gas disasters, passing on the cost of retrofitting underground gas lines and transmission lines, putting them underground, and the fact that we have the second or third highest natural gas prices in the United States, and Diablo Canyon is also part of that high cost.

**Alison St. John:** So thank you so much. So Mark will be here over lunch and he will be available I think. So the interesting thing is that you're showing why nuclear is not a viable option in spite of what people are saying, including Bill Gates, that this is, you know, the only way through to react to climate change. But the problem of the waste is actually the least of what you're saying is the problem. There's so many it doesn't pencil out. It's not efficient. So that's a very important perspective.

**Alison St. John:** So I'd like to move to Leona Morgan next because in some ways what Leona is here to tell us is going to help us understand what the problem is with one of the solutions that was suggested in a previous panel, consolidated interim storage. And I think a lot of us living here in San Diego County think that there's a move afoot to find some other communities that will take the waste and that will solve the problem. So Leona is in one of those communities in New Mexico where that was a proposal. And so, Leona, I'd like you just to talk a little bit about what your community, how they reacted to that proposal and what would you say to people here in San Diego who are hoping that it will go to New Mexico?

**Leona Morgan:** Can you give us a time breakdown? Because I know we're over time.

**Alison St. John:** How much time would you...

**Leona Morgan:** I would like equal time as Mark.

**Alison St. John:** I have to say Mark overstepped his time and I'm hoping that nobody else will, so go for it.

**Leona Morgan:** How many minutes

**Alison St. John:** 10 minutes.

**Leona Morgan:** Ok, well I was asking for equal time as Mark, but it seems only fair, however I have much more information to share but you all can find me at the break or ask questions.

**Leona Morgan:** (Leona introduces herself for our non-human relatives and ancestors, and her relatives at home).

**Alison St. John:** I would just like to let everyone know that Leona is Diné which is a part of the Navajo Nation. Can you tell us what it is you were explaining to us?

**Leona Morgan:** Thank you I was introducing myself. And I will not interpret that because that was for our non-human relatives, and our ancestors, and my relatives at home and everyone watching. I'm from a place called New Mexico, and I want to start by just explaining and introducing myself that I am coming from a place of privilege to be sitting in this room amongst you all. I have incredible privilege. I went to college. I'm in graduate school. My parents both had good jobs and they were not alcoholics. And we lived in a house with running water and electricity. I did not have to drink contaminated water growing up. I do not breathe contaminated air because I don't live near a contaminated site. However, there are over 23,000 abandoned uranium mines across the country. At least 500 on Navajo Nation. California has the most. And so I'm in school for planning. I'm working on a master's of community and regional planning, and I just have so many responses to the things I've heard this morning. There's a lot to share and there's a lot of things I'm sure folks here have never even heard of, will never experience. And maybe some people really don't care about some of the things I'm going to explain, because it directly impacts all of you, the citizens of California, the United States, anyone living near reactors, any of the nuclear workers depending on these jobs to feed their families.

**Leona Morgan:** I'm going to tell you all there is no energy transition that is going to supply the human consumption that exists today. We must reduce our energy consumption. Renewables and everything that's being pushed are only creating a new disaster for indigenous peoples and people who live near the minerals needed for those energy sources. The batteries, the cobalt, the lithium. So all of the things needed are going to hurt people somewhere. Nuclear has hurt my people. And so I just want to do a brief history lesson if I could. How many of you in the room you can if you would, wouldn't mind showing

your hands. I'm just curious how many of you guys know about uranium mining? Great. How many of you have heard of the Radiation Exposure Compensation Act or RECA? Great. How many of you know what is the Doctrine of Discovery? Awesome. How about the mining law of 1872? All right, you guys get prizes. So these are the things that are impacting my people and indigenous peoples across Turtle Island, not just in the United States, but in Canada as well. And so I keep hearing this need, this determination to create safety for the people.

**Leona Morgan:** But I ask, what people, what people are you trying to protect? Who are you trying to protect? What communities have been brought to the table? And so a planning process of one year is really ambitious. It's probably too ambitious. As a student, I make all of my planning projects 18 to 24 months, but I'm still a student because you need that pre-evaluation time. Who are the stakeholders? Who is impacted? Who should be at the table? So you're probably thinking, oh, these towns, these communities, the County chamber of Commerce, the churches, the schools. How many of you have even gone to a single indigenous nation to talk to them and ask them, what do they want? What are their concerns? Good job. Great. I wasn't expecting that, I was not even expecting a response for that. But I'm really happy to see that some folks have actually gone out there. And I think this is the most important thing for folks to understand. When you're talking about nuclear, the waste doesn't just magically appear at the reactor. Nuclear energy is the most expensive, most complicated, dangerous, slowest way to boil water. And it is also a tool of colonization and genocide. So from the mining...

**Alison St. John:** (Unintelligible)

**Leona Morgan:** And so as I was saying, I sort of lost my train of thought here. I don't think Mark was interrupted as much as I have been in my short five minutes of speaking.

**Leona Morgan:** So uranium mining, we have the beginning of the nuclear fuel chain. There's so many abandoned uranium mines. How many mines are actually operating today? I don't know if anyone knows. There's several operating at this time, mostly in the Intermountain West. The flyover states, the states that are often ignored, often erased, just like indigenous peoples have been. The history of our people goes all the way back to time immemorial. And so when we're talking about things that started this nuclear waste pile about 80 years ago, it's going to take a lot longer than one year to plan our way out of it. And so going back to the doctrine of Discovery that was written in 1493. So after Columbus got

lost, he realized, oh, wow, there's a bunch of stuff over there. Let's get it. So 1492, everyone knows what happened. Then in 1493, Columbus went back to Europe, and then the papal bulls wrote this thing called the Doctrine of discovery. And this is the basis for most Western governments and pretty much most institutions that exist today that basically says it's God's will or whatever, that these people, they didn't say people, these animals over there are not human.

**Leona Morgan:** They are less than human. And therefore it's okay to enslave them, to kill them, to clear the land, which is what we call removal, the Indian removal period. So there was a systematic process that took place going back over 500 years to land in the position of where we are today and the creation of the United States. The United States was founded. 1872 mining law, AEC, NRC, DOE. All of these things that we're dealing with today, it's just a separation of that initial monster of colonization. And so essentially the entire system that we live in is built on institutional racism that feeds off the resources of our people and basically destroying our cultures. Right now, I am working on an issue to stop a uranium mine. The uranium mine is a few miles south of the Grand Canyon, and the indigenous people that live at the bottom of the Grand Canyon, the Havasupai, have been fighting this since the mine started in the 80s. This is their homeland. So the mine is about four miles from their place of emergence. They have less than 600 people in their tribe. So there's about 574 federally recognized tribes or indigenous nations in this country.

**Leona Morgan:** This is one that is telling the world, if you do not shut down this mine, we are going extinct. So they're taking uranium out at the Grand Canyon. Energy Fuels owns that company, owns that mine. Energy Fuels is the company that owns the only conventional uranium mill in the country. So there's only one place processing uranium. But this facility doesn't just process uranium. It also processes what's called alternate feed. So it's acting as a waste dump for other nuclear materials somewhere else in the world. So they're using this license of alternate feed to process waste, to say "oh yeah, we're going to produce uranium out of this waste." But the reality is, whoever's sending them the waste just has nowhere to put it, such as Japan. So there was just a shipment of radioactive waste that came from Japan that went to the White Mesa mill. And the reason I'm bringing up the White Mesa mill is because this is a very sensitive point of the nuclear industry. It's the only conventional mill in the country. If we could shut it down, we can shut down uranium production, at least for some time. I don't know if this matters to you all, but it matters to me because the president of the United States just promised to triple nuclear power development by 2050, and then only a few weeks after that, he also signed into law the Nuclear Fuel Security Act.

**Leona Morgan:** So what does this mean? More domestic uranium production? For whose nuclear power plants? There's no nuclear power plants in New Mexico, but that's where they wanted to send all of the waste. 173,600 metric tons, more than double what existed at the time of the licensing. We fought Holtec in New Mexico and we won. New Mexico does not want your nuclear waste. New Mexico does not want anyone's nuclear waste. And we will not take it. The state of Texas also fought this. So there were two proposals for consolidated interim storage and both have been shut down right now. So we fought these through state laws in both New Mexico and Texas. After both states passed laws, the NRC still gave the license, and so now they were also fought in court. And we're going to see if these are taken up in the Supreme Court. So that's where the status of these are now. So we say this is illegal. And in New Mexico on a state level it is illegal. And Texas. So that's where we're at with those.

**Audience:** (Audience applause)

**Leona Morgan:** Yeah, thank you, thank you for that.

**Alison St. John:** Sorry I need to...

**Leona Morgan:** I need a couple more minutes.

**Alison St. John:** I'm sorry I cannot let you, I'm being asked...

**Leona Morgan:** I asked for the same time as Mark.

**Audience:** (Audience asks for Leona to have additional time).

**Alison St. John:** Ok, so Bart says thumbs up, so lets do it.

**Leona Morgan:** I just want to highlight that the title in the program is incorrect. The nuclear issues study group no longer exists. I am a co-founder of this campaign called Haul No. And what we are working on is the transport of the uranium from the Grand Canyon through my nation to the White Mesa mill. And the White Mesa mill is the home of many indigenous nations right now. The Ute Mountain Ute Nation is fighting the mill because the mill uses an inordinate amount of water, and we're in the middle of the desert. Nuclear uses a lot of water. Nuclear creates a lot of radioactive water. All of the machinery, everything that touches anything nuclear becomes radioactive waste that we have nowhere to put. The White Mesa mill is a few miles north of the Ute Mountain Ute community, and I spoke to one of their high level officials and he called me. I'm a community activist. I'm not a government person. I'm not a doctor. I'm not a lawyer. I'm not, you know, these experts that are all in the room. I'm a community organizer, and that's what I do. And so this chairman of his tribe, he contacted me because of his concern for their water. And he said because of the lack of water, the reduction of water because of climate change and the amount of contamination that exists there, there are people can no longer survive there. And he's talking about planning for relocation. So right now, because of climate change, a lot of indigenous nations are working on what's called climate adaptation plans, caps, so they can adjust their culture, everything because of climate change.

**Leona Morgan:** San Onofre is an example of a huge problem. Imagine if that was your indigenous nation and all of your philosophies, worldview, prayers, future are on that coastline, which is eroding every day. And so indigenous peoples are planning for their own relocation as it's necessary because of climate. So the White Mesa community could be a community that is moved because of nuclear. This is a modern form of nuclear colonization. It's not like 1872 where they're staking claims, literally taking our land for no repayment to the United States except for $10 a year. So the 1872 mining law allows any company- a long time ago it was people mining by hand- that mining law says any entity can mine on US public lands. They don't have to pay for the land, but if they stake a claim and can prove there's valuable minerals, they can take ownership of that land for a fee of $10 a year less than that. So this is the law as it stands today. There's no requirement for royalties. The good thing is, since then, the EPA came into existence and now there's some environmental oversight. So before the EPA existed, there was this uranium boom from the 1950s to the 1970s that created thousands of uranium mines in the country. There was no law to clean those up.

**Leona Morgan:** So today there's thousands of uranium mines blowing around radioactive dust in the country, about 23,000. So I agree wholeheartedly with what the Admiral said that we need to address

this waste problem. But I think we need to look at the totality of the waste going back to the front end of the nuclear fuel chain, uranium mining, milling, enrichment, fuel fabrication, every step on both routes of energy and weapons. There's a lot of things coming down the pipelines right now. We're looking at I mentioned, the tripling of nuclear power, the Nuclear Fuel Security Act and then also the United States let RECA go. So there's no money in place for people or human health. It's only trillions of dollars for new nuclear weapons. So in New Mexico we're dealing with plutonium pits, plutonium pit production, and also expansions at whip. Whip was opened in 99. It was supposed to close this year, but they want to keep it open. They would keep extending it. They want to keep it open forever, expand it physically and also add different types of waste that Whip will hold. So in New Mexico we have so many nuclear facilities, and I know we don't have time to talk about all of them. Some of my concerns besides small modular reactors. There's also nuclear hydrogen.

**Leona Morgan:** So on our nation, we're dealing with a push for hydrogen and all kinds of things. So I'm just going to wrap up by saying, we're asking the governor of Arizona to shut down the Pinon Plain uranium mine, because that is the first mine to start in Arizona. Energy fuels started mining in Utah earlier this year as well. So there is new mining now, and I believe that is because of that push from Biden. He signed on August 8th a national monument to protect the Grand Canyon, almost a million acres from new mining forever. There would be no mining, but that was only for the claims from 1872 mining claims. Those are just plots of land. There's no uranium mines there. The uranium mines that were already in existence and had valid existing rights were all grandfathered in. So even though there's this new national monument a few months later, this new uranium mine started. And so the people down in the canyon, the people on the haul route, and the people at the mill were all asking everyone to help us. If you want to stop your nuclear waste problem here, help us to stop it at the beginning. The Ute Mountain Ute community invites everyone to join them for a prayer walk on October 12th at the White Mesa Community Center. They walk from the community to the mill, and so this could be a good experience for folks to see what they live with every day.

**Alison St. John:** That was exactly what I think all of us need to hear, that we think our problems are going to be solved by sending it somewhere else. So this was the most powerful presentation of why that is not going to work. So now Deanna Polk moving on and to sort of make a link again, I think what you're going to be telling us is exactly why, the the nuclear industry as it exists now is not taking care of our safety because you've been involved with emergency response and you've heard they don't have answers for a lot of your questions. So I would like you to communicate that to our audience here.

**Deanna Polk, RN:** Thank you. First of all, I'm honored to be invited here as an emergency substitute for Cindy Folkers, who did some excellent work on the Radium Girls and Maternal child health. I was asked to speak on the medical implications of radioactive waste. And just a quick recap for the Radium Girls were back around World War I, they painted watch faces with the radium paint to glow in the dark, and they thought it was going to be a great asset to the war. Cindy Folkers went into the history of the Radium Girls and how they died, horrible deaths. And that was the first medical research really done into the hazards of working with radioactive materials. And in that you will find the political backlash and all of that. It's hard to get people engaged in a passionate exchange about a health threat that you cannot see, hear, taste, touch, or smell. It can be a very complex, very detailed, you can get into the different types of radioactive materials; strontium 130, cesium 137 and what they do to the body.

**Deanna Polk, RN:** I think most of us are familiar with acute radiation syndrome. And that's the very intense, deadly, large exposure. The one thing with medical threats regarding radiation and other other other chemical agents is time, dose and distance. So you can have an intense dose in a short period of time, like Fukushima and the heroes that ran in to stop that and how they died, the same thing at Chernobyl. But that only touches around one area. It's hard to get medical data on a threat that has been covered up and not recognized for so long, such as uranium mines all over our First Nations and other industrial applications. So it's very hard in 5 or 10 minutes to give you all the medical implications of this. It attacks your fast moving cells first. So your blood system is hemopoietic. Then you have gastrointestinal, you have neuromuscular and you have skeletal issues. And it depends on the route of contact with the offender. Whether it's in the air you're going to breathe it in, if it's on your food, you're going to ingest it. And that starts off different symptoms. The problem is we have so many radioactive sources throughout our country, and the fight against research in connection with the increased rates of cancers in children. Children are the most susceptible, and one of the first cancers are leukemia. The thing that we need to get our society, our world to understand is being that you can't see, hear, taste, touch or smell it and it does not go away. You cannot neutralize radiation. You can prevent it from happening. You can do lead containment and all of that to a certain extent. But when you don't know where the houses are, you don't know how to prevent those health effects from happening.

**Deanna Polk, RN:** I have been an emergency responder planner and I formed and conducted the first decontamination response team at Scripps La Jolla back in 2002. And in having to monitor these drills and protect the health of my patients and my employees, we found so many holes. That's what I'd like to speak with. The holes in protecting our health. I've worked on local, state, federal, and global issues regarding disaster response and radioactive being one of them. What I found out through my

governmental agencies in dealing with these health effects was, a lot of times you're going to have people that will sanitize reports because they're tied into grants, and they want to make sure they meet their deliverables.

**Deanna Polk, RN:** And I encountered that at our emergency operations center. And in finding out the truth of just how many releases we've had, how do we know how much when we do not have scientific, proper monitoring? And some of the questions I asked the NRC, somebody had asked about a disaster response plan. They said, "oh, we have an emergency response plan and we drill it." And I raised my hand. I was scared to death. I said, "well, does that incorporate just the ten miles around the plant as mandated by NRC, or does it involve the whole community as outlined by Homeland Security's IS800 Advanced Threat and Risk Assessment in which I'm credentialed?" And he shut his mouth. I mean, his jaw dropped. And then I said, "because I know for a fact that our hospitals do not have radiation detectors. We do not have enough staff trained." We looked good on TV. And it was a great effort. However, the money it costs to train people and have ongoing training. And you've got to think about this not only at a hospital level, but you're mandated reporters, your police, firefighters, school bus drivers, teachers.

**Deanna Polk, RN:** If you look in the emergency response plan and see who is mandated to become a first responder, you need to beg the question, how much training do they have on them right now if an event happened? What kind of personal protection do they have right now on them? In case of an event, how do you decontaminate an ambulance? How do you evacuate farm workers? How many of the 85 languages spoken in San Diego County is our safety information disseminated in? I could go on and on and on because everybody says, "oh, well, the experts will take care of it. And we have a plan. And see, according to this contract, we've tested and drilled and we met the criteria to meet our grants." But those of us working in the field are going, "Oh. Well, it looks good, but we're dead. We're dead." We're dead because I asked outside of the Public Utility Commission hearings where they wouldn't let me testify in person, I asked the state trooper that made our cameraman leave, I said, "what do you have on you right now? If an event happened" and he goes, "well, N95 masks and some purple gloves."

**Deanna Polk, RN:** And how many of these people that are mandated reporters are going to be more worried about their families, their own safety and their children. We only have two evacuation routes out of San Diego County. Interstate five and eight East. We have an independent nation to the south of us that has a border they will want to keep secure. And what does that do to their people? One of our

evacuation routes goes north and south where we have major gas lines and it's in earthquake country. What if an earthquake happened and we shut down that one route? The emergency response plans look good. They get lots of money. But they are not valid. They are not keeping you safe. To me, this is the most important health aspect in humanity right now because of the long life of radioactivity, because of the altering of the DNA that you may not see in yourself, but in your children and in your grandchildren. And I'm a walking testament to that, because I lived in Camp Lejeune for ten years of my youth. I've suffered a lot of medical implications. I still haven't got a penny from them, but I now see problems in my son and in my granddaughter that can be traceable to that exposure, and it breaks my heart.

**Deanna Polk, RN:** What are we going to see in the future with our capacity to think? Not to mention the overloading of our health care facilities, people are being turned away from cancer treatments, children not being able to get the medications. Even radiation oncology, my goodness, the stuff we had to do to keep ourselves safe and what we have to do to monitor and teach the patients to keep themselves safe and their families through different therapies, whether it's ingestion of a radioactive iodine capsule or a fluid and how your urine has to be collected. And there's a lot of people that do not have the education and training that are working in healthcare right now to prevent exposure. So one of the things that got me was I was just reading, May 24th, Orange County Register, they had a report and that showed the increase of cancer in our youth in Orange County is far outpacing surrounding counties. That needs to be taken a look at.

**Alison St. John:** That final point that Deanna made is so, so powerful because, it might not be that there is just a leak. And we hear about it and we all panic. It might just be a long, slow process. Yeah. Who would like to ask a question right here?

**Audience:** Thank you so much. Hi there, thank you all panelists. My name is Shaeli Chapman. I'm a military spouse on Camp Pendleton. I wanted to address the Camp Lejeune point that you made, and the longer effects of radiation that maybe we're not seeing, we're not smelling, we're not tasting right now, but what that looks like 20, 40, 50, 100 years down the line. When we talk about Camp Lejeune, it's been a very kind of more sensationalized issue. The Pact Act has got a lot of bipartisan support. Do you think that there is the possibility of framing the issue of San Onofre and greater radioactive waste containment from that military perspective? Do you think there's a possibility to kind of get some support from that angle?

**Deanna Polk, RN:** That's the point I wanted to bring up, because I do hold a master's of science in homeland security. And so one of the threats is the health and safety of our military personnel near these plants. Right now at risk are all the military and dependents. We could take down the whole fleet if we had an event right now so you would think that the military and the people looking at the security of our nation would want to take a look at these threats because of the potential. I mean, if we had an event at San Onofre right now, it would take down Camp Pendleton, probably Naval Air Station, the whole pack fleet, El Toro. I'm a military kid, and I worked hand in hand with the Navy throughout a lot of my adult life. I look at it from a security standpoint that, oh, my goodness, you don't want to take down your first line of defense here. But the people that have to go with them, the spouses and the children that have no say in where they go. So to me, Homeland Security should be on this, but they're on a different tack. From an expert standpoint they should be checking they should be on this- our Marine Corps, Navy, Army, and Air Force. They should have this front and center as a threat to the safety of their troops. Thank you.

**Leona Morgan:** Thank you for that reminder. And so just to give you guys some idea about the lack of attention to health or, you know, humans that the nuclear industry and the federal government pay attention to or actually fund. I like the NRC's mission, I forget, was it to protect the people and the environment or something like that? I think that's what it's supposed to be. I thought radiation doesn't discriminate, but I want to just acknowledge Mary Olson and Cindy Folkers, who do a lot of work on gender and radiation. And it is very clear that radiation does discriminate. And women and children, girls, fetuses are the most impacted. And so we need to acknowledge the generational impacts when right now the hibakusha who are living, there's very, very few of them who experienced those nuclear blasts on August 6th and August 9th. But what is the generational impact to the Japanese people? Have they studied it? I highly doubt it because of the Japanese government propaganda about peace time use and military use. Well, when it comes to uranium, it doesn't matter. It's all deadly. It's all toxic. All of it kills, whether it's for energy or weapons. They did a research project out of UNM called the Navajo Birth Cohort Study. And so, just to summarize, I can't go through the whole thing, you can talk to me or Google it, but they found levels of uranium in newborn babies at the same level as a nuclear worker.

**Leona Morgan:** These are newborn babies on the Navajo Nation today. This means the generation of women giving birth. They didn't live near a contaminated site. This is all across the Navajo Nation, mind you. We're also downwind, many of us from the 900 plus nuclear tests in Nevada. So there's a lot of studies that probably will never be done because they don't want the information. The things that we know exist, that we're the living experience of that. And so I just I know we're over time, but there's one

thing I just wanted to add to all of this stuff. It's horrible, it's deadly, and there's a lot of things people can do. I just wanted to point out, I don't think anyone talked about how the carbon of nuclear energy is measured. And so we really need to make policies and enforce laws to show the reality and the harms of these things. And so all of the health, all of the emissions, all of the energy, everything we need to be real about this stuff. But one of the most glaring atrocities of the nuclear industry is that they're pushing this lie of atoms for climate. That's the new one, because they do not measure the carbon footprint of the full uranium fuel chain. They only measure it at the nuclear power plant. So they erase all of the steps before and of course, the most deadly stuff that lasts forever, which we're all here to talk about, which is the high level radioactive waste. So let's get that changed.

**Alison St. John:** Well, as you can tell, we could be here a week and we'd just be learning more. Such a wonderful panel. Thank you so much.

## Panel Two: Why Are We Worried?

**Lance Gould:** Thank you, Alison, and welcome to our virtual lunch panel. I'm aware that conducting a panel during lunch means that what we discuss now will have to compete with the salmon. So we brought our A game this afternoon. We refuse to take a back seat to a fish. But in all seriousness, this is a topic so urgent that we are keen to have your attention and to discuss the deadly nature of radioactive waste. There are 3.6 million pounds of radioactive nuclear waste buried past their perishable date casks, just 100ft from the Pacific Ocean. Did we mention this was all in an area so seismically active it is known as earthquake Bay? That begs the question for which this panel is named "Why Are We Worried?" And to answer that question, we are delighted to be joined by two distinguished experts on nuclear energy and radioactive waste, Dr. Paul Dorfman and Dr. Gordon Edwards. Dr. Dorfman is visiting fellow at the Science Policy Research Unit, University of Sussex. Chair of the Nuclear Consulting Group, and a member of the Irish government's Environment Protection Agency Radiation Protection Advisory Committee. And Dr. Edwards is the co-founder of the Canadian Coalition for Nuclear Responsibility, and has been its president since 1978. He has worked widely as a consultant on nuclear issues, and has been qualified as a nuclear expert by courts in Canada and elsewhere. Thank you for joining me, gentlemen.

**Lance Gould:** Let's get right to it. Gordon. Let's start with you. The San Onofre nuclear power plant, known as SONGS, was permanently shut down in 2013 and began decommissioning in 2014, about a

decade ago. The name of this panel is again, "Why Are We Worried?" So please tell us precisely why we should indeed be worried.

**Dr. Gordon Edwards:** Well, thanks, Lance, that's a good question. If nuclear power were just generating electricity and nothing else, it would be safe. But it's also mass producing deadly radioactive poisons that were never found in nature before the nuclear age began just 85 years ago. For instance, if you look at nuclear fuel, it can be safely handled before it goes into the reactor, but after it comes out, it is millions of times more radioactive, and it will kill any nearby human being in a matter of seconds by an enormous blast of gamma radiation. So what makes the used fuel suddenly so dangerous? Well, inside the fuel, there are literally hundreds of brand new varieties of radioactive elements that were created by the splitting of uranium atoms. For example, you might have heard of iodine 131, cesium 137, strontium 90. These are radioactive varieties of non-radioactive elements that exist in nature all around us. They're human made radioactive poisons. They're sort of like evil twins. For example, if you look at ordinary table salt, it has a little bit of iodine added to it. It's not radioactive. It goes to the thyroid gland and helps to prevent a terrible, disfiguring disease called goiter. Well, nuclear plants produce radioactive iodine. It also goes to the thyroid gland and causes cancer. 6000 children in Belarus had to have their thyroid glands surgically removed because of radioactive iodine from the Chernobyl accident of 1986. In northern England and Wales, for 30 years after Chernobyl, sheep farmers could not sell their meat for human consumption when it was contaminated with radioactive caesium to this day. Hunters in Germany and Austria who kill a wild boar cannot eat the meat because of radioactive caesium contamination. You know, everything is made up of atoms. The only difference is that radioactive atoms explode.

**Dr. Gordon Edwards:** It's called an atomic disintegration. Radioactive atoms are like little time bombs. If they explode inside you, they damage living cells, especially DNA molecules. When the DNA is damaged, it may make things grow in an unnatural way. Radiation damaged cells can and do develop into cancers of all kinds. What's even worse, if the reproductive cells are damaged, the eggs or the sperm, genetic illnesses can be passed on to children and grandchildren, and this danger remains as long as the radioactive wastes remain, which is essentially forever. Every radioactive material has a half life. That's how long it takes for half of the atoms to disintegrate. Now, some have very long, half lives. Plutonium 239, for example, has a half life of 24,000 years. That's five times longer than the Egyptian pyramids have existed. And when a plutonium atom disintegrates, it turns into another radioactive material that has a half life of 600 million years. So radioactive wastes remain dangerous for millions of years. They are the most toxic wastes ever produced by any industry, ever. They are essentially indestructible. Countless

billions of dollars are planned to be spent to keep these materials out of the food we eat, the water we drink, and the air we breathe. At Hanford in Washington state, just north of California, the radioactive cleanup is estimated to cost more than $300 billion, according to the General Accounting Office. By building more reactors, we're just adding to the existing burden. In fact, you could say the real product of a nuclear reactor is radioactive waste and plutonium, which remains dangerous for millions of years. The electricity is just a little blip, a short term benefit for a few decades. The radioactive legacy lasts forever.

**Lance Gould:** So disturbing. Thank you for enlightening us with that. Gordon, can you put some of this in context? Tell us about the history of nuclear waste, because it takes, as you noted, anywhere from decades to millions of years to lose its half life toxicity. So, for example, what about the radioactive waste from the very first nuclear power plant built in 1951, in Idaho? Must that nuclear waste be stored forever, or is it to be able to be recycled? And would recycling solve the nuclear waste problem?

**Dr. Gordon Edwards:** Well, Lance, that's a good point because the very first reactors, in fact, did not produce electricity. They were built for the express purpose of creating plutonium for atomic bombs. Plutonium is a uranium derivative created in the reactor. It's one of the hundreds of radioactive byproducts that are created inside every uranium fueled reactor. Plutonium is the stuff from which nuclear weapons are made. Every large nuclear warhead in the world's arsenals uses plutonium as a trigger. But plutonium can also be used as a nuclear fuel. That first power reactor that you mentioned started up in 1951, in Idaho. The first electricity producing reactor in the world was called the EBR one. It actually suffered a partial meltdown by the way. EBR stands for Experimental Breeder Reactor and it was cooled not with water but with hot liquid sodium metal. Now the dream of the nuclear industry was, and still is, to use plutonium as the fuel of the future. Replacing uranium. A breeder reactor such as the first one is one that can burn plutonium fuel and simultaneously produce even more plutonium than it uses. By the way, another sodium cooled electricity producing reactor was built right here in California, and it also had a partial meltdown. In fact, sodium cooled reactors have failed commercially all over the world in the US, France, Britain, Germany and Japan.

**Dr. Gordon Edwards:** But it's still the holy grail of the nuclear industry. So watch out. There's a lot of pressure right now to get back into the business. To use plutonium, you have to extract it from the fiercely radioactive used nuclear fuel. This technology of plutonium extraction is called reprocessing. It must be carried out robotically because of the deadly penetrating radiation from the used fuel. Most reprocessing involves dissolving used nuclear fuel in boiling nitric acid and chemically separating the

plutonium from the rest of the radioactive garbage. This creates large volumes of dangerous liquid waste that can spontaneously explode, as they did in Russia in 1957, or corrode and leak into the ground, as has happened in the USA. A single gallon of this liquid, high level waste is enough to ruin an entire city's water supply. Now, in 1977, US President Jimmy Carter, who was trained as a nuclear engineer in the Navy, banned reprocessing in the USA because of fears of proliferation of nuclear weapons both at home and abroad. Three years earlier, in 1974, India tested its first atomic bomb using plutonium from a Canadian research reactor that was given to India as a gift. The problem with using plutonium as a fuel is that it is equally available for making bombs.

**Dr. Gordon Edwards:** Any well-equipped group of criminals or terrorists can make its own atomic bombs with a sufficient quantity of plutonium, and it only takes about eight kilograms to do so. Even the crudest design of a nuclear explosive device device is enough to devastate the core of any city. Plutonium is also extremely toxic especially when it's inhaled, a few milligrams is enough to kill any human being within weeks through massive fibrosis of the lungs. A few micrograms that's a thousand times less can cause fatal lung cancer with almost 100% certainty. So even tiny quantities of plutonium can be used by terrorists in a so-called dirty bomb. That's a radioactive dispersal device using conventional explosives. Just a few grams of fine plutonium dust could threaten the lives of thousands if it was released into the ventilation system of a large office building. So beware of those who talk about recycling used nuclear fuel. What they're really talking about is reprocessing and plutonium extraction, which opens a Pandora's box of possibilities. And the liquid waste and the other leftovers are even more environmentally threatening, more costly and more intractable than the solid waste. Perpetual isolation from the environment is still required.

**Lance Gould:** Thank you doctor. Paul, let's talk about climate change in the grand scheme of things. As Dr. Edwards just noted, nuclear energy is not that old. The first nuclear powered electricity dates back, as we just mentioned, to 1951, less than 75 years ago. And it's just noted with Gordon because the half life of waste can be thousands or even millions of years, we can't really predict, scientifically speaking, what kind of issues that can lead to when it's disposed. So now how does the addition of climate change factor in here? The negative impacts of climate change are dangerous and unpredictable. Tell us how that could impact radioactive waste.

**Dr. Paul Dorfman:** Okay, so the IPCC, the International Panel on Climate Change says that we must significantly cut CO2 emissions by 2030, to have a chance of hitting 1.5 degrees. The IPCC 2023 summary

report, the most recent report by the International Panel on Climate Change, says that renewables are now ten times more efficient than nuclear at climate mitigation. Now, in terms of, say, Cop 28, you know, the ambitions for Cop 28 were to triple nuclear capacity and to triple renewables capacity. If you look in detail, what they say was to triple nuclear capacity to 1.2 terawatts by 2050, that's 1.2 terawatts of nuclear by 2050. On the other hand, the ambition is to triple renewables capacity to 11.5 terawatts by 2030. So 1.2 terawatts plays against 11.5 terawatts. 2050 nuclear plays against 2030 renewables. So you're seeing, in live moment exactly what's going on here. Now UK government global data including planning and regulation, reports just one nuclear power station takes up to 17 years to put down, and that's about ten years of construction. So 17 years to put down, including ten years of construction. So if you look at our problem with climate, the simple reality is we just don't have time for new nuclear. I mean, it's a simple equation. It's in fact not, not up for grabs. And if you're looking at what happened to total total electricity last year 2023, 86% of all new power capacity additions worldwide was renewables with nuclear nowhere. So we see quite clearly, what's happening and where this trajectory is going.

**Lance Gould:** Thank you, Paul. As you noted in referring to the UN, IPCC report, which is the Intergovernmental Panel on Climate Change, the IPCC report which synthesizes thousands and thousands of of science research papers, noted that we must move away from fossil fuels as quickly as possible to avoid the potentially irreversible negative consequences of climate change. And yet some, as you noted, even in the green sector, point to nuclear energy as a viable alternative to fossil fuels. Tell us why that might not be true, that nuclear energy is not a viable alternative as a clean energy.

**Dr. Paul Dorfman:** It's just too late. It's just too late, and it's just too expensive. All of the recent, generation three reactors are hugely over cost and hugely over time. SMRs are well into development, which means that we won't be seeing any of this into the late 2030s and only the beginning of some form of nuclear construction by the 2030s.

**Lance Gould:** But is it even clean when people point to it as a clean energy alternative? Is it fair to say that nuclear energy is clean?

**Dr. Paul Dorfman:** No, no, it's completely unfair to say that nuclear energy is clean. It's very dirty. As our colleague has just stated, it produces very significant, very problematic waste, very problematic pollution, very problematic issues associated with incident and security. In an increasingly insecure

world, nuclear power, unfortunately, look increasingly like good targets. Now, the question is, why would we want to go with such a technology or increase this kind of technology if we have clean, green, efficient, practical, renewable, cost effective technologies, which we do have? And let me remind you, 86% of all new power capacity worldwide last year was renewables.

**Lance Gould:** That makes so much sense. Thank you. Dr. Gordon, back to you. Let's talk about rolling stewardship. From what I've read of your work, it seems even the way we think about nuclear waste is problematic. We think of it as something we can almost literally sweep under the rug. But that's not exactly going to work. But you've suggested that rolling stewardship is an alternative to deep geologic disposal. Tell us more about rolling stewardship.

**Dr. Gordon Edwards:** Yes. Well, it's really trying to get away from the lies. The problem is that there are too many lies surrounding our decision making, and they give us to false decisions. Rolling stewardship is a concept put forward by the National Academy of Sciences in connection with other long lived toxic waste, like heavy metals and asbestos. The basic idea is that when you don't have a solution to a waste problem, you have to be careful not to abandon the waste. We have to continue to look after it on an intergenerational basis, passing the responsibility, the knowledge and the resources to the next generation. With the object of continually improving safe storage. For the first 30 years of the nuclear age, until the mid 70s, no one knew about radioactive waste because the nuclear industry didn't tell anyone about it. People were told that nuclear power is clean and they believed it, but it was a lie. In the mid 70s, radioactive waste suddenly became public knowledge. Major reports in several countries called for a halt to nuclear power unless the problem is solved. So all of a sudden, the waste problem became an existential threat to the industry and self-defense. The industry claimed, without any real evidence, that they had a solution, bury the waste in an undisturbed geological formation. But of course, the moment you dig it is no longer undisturbed. We've already seen three deep underground repositories for lower level nuclear waste fail, two in Germany and one near Carlsbad, New Mexico. The USA has actually tried eight times to locate a deep underground disposal site for radioactive waste, and they have failed all eight times. Here in California, to the credit of Californians, in 1976, hundreds of thousands of people signed the citizens initiative to stop any new reactors from being built in the state because there is no waste solution that was passed into law and it's still the law.

**Dr. Gordon Edwards:** The legislature asked the Energy Resources and Conservation Commission to see if there is a safe disposal method. After two years of public hearings, the verdict was no. The commission

chairman said in 1978, "we think it probable that safe permanent disposal will never be demonstrated. Excessive optimism about the potential for safe disposal of nuclear waste has caused backers of nuclear power to ignore scientific evidence, pointing to its pitfalls. That's the real crux of what we found, that you have to weigh scientific evidence against what is essentially engineering euphoria." So rolling stewardship is not a solution, but an acknowledgment that we do not have a solution. Instead of abandoning the waste underground, we should monitor it and make sure it is retrievable. Instead of waiting for the containers to fail or fall apart, we should repair and repackage and improve the safety measures from one generation to the next. Instead of assuming a solution exists, we should recognize that there is no proven solution, and therefore, instead of abandoning the waste, we should look after it. We should keep it monitored and retrievable. Instead of closing the door on research to find a genuine solution, rolling stewardship will keep that quest at the forefront of human consciousness. This may sound idealistic, but in fact it is simply realistic. The worst thing about self-deception is that you end up with a mess of vastly inferior and dangerous form of rolling stewardship, because it was not planned at the outset.

**Lance Gould:** Well, that gives us a ray of hope. The idea of rolling stewardship just to at least have some, developing solution to the problem. It seems there's a connection, at least in name, Gordon, between one of the most famous ever surrealistic paintings and rolling stewardship: The Persistence of Memory. Tell us about that aspect of rolling stewardship.

**Dr. Gordon Edwards:** Yeah, that's another good point, Lance. One of the worst things about abandoning radioactive waste, which is what the industry wants to do, is that over the very long term, amnesia sets in. Everyone forgets where it is or what it is. So when it leaks out into the environment and it will leak out sooner or later, no one knows how to even detect it or to deal with it. Rolling stewardship, on the other hand, is predicated on the persistence of memory, the knowledge of these highly toxic wastes, and how to deal with them. It has to be kept alive from generation to generation because it remains an ongoing threat. In 2019, I attended a three day conference in Stockholm about how to warn future generations about the legacy of radioactive waste we are leaving behind. We don't know what language people will be speaking in 2000 years or in 10,000 years. So how do we warn them? Do we put up a sign saying, "do not dig here"? Will they understand the sign? And if they do understand it, will they obey it? If I were a future archaeologist who came across such a sign, I would say to my team, "hey, let's dig here." The Stockholm conference was an interesting affair. One third of the participants were nuclear scientists, one third were independent commentators and critics such as myself. One third were librarians and archivists who knew little about radioactive waste, but lots about preserving records,

memory and knowledge. We were all aware that the problem we're addressing is similar to the problem of communicating with extraterrestrial intelligence.

**Dr. Gordon Edwards:** How do we communicate with no assurance that they understand any of our languages? So one of the advantages of rolling stewardship is that one can more easily pass on knowledge, information and advice from one generation to the next rather than trying to communicate with a completely unknown society of the future. One of the conclusions of this discussion is that decision making about radioactive waste can no longer be left solely in the hands of the nuclear industry and its captured regulator, the NRC. We have to plan to address it, to address the future. So we need to have a radioactive waste and nuclear decommissioning agency that is independent of all the promoters of nuclear energy, whether commercial or governmental. We need an agency whose sole focus is the protection of people and the environment. We need an agency that communicates openly and transparently with citizens about the nature of the problem and the range of the options. As long as we continue to build and operate nuclear reactors, we're simply compounding an already intractable problem. No matter how fast we bury the old waste, the surface of the Earth will always be prone to catastrophic releases from the freshly produced nuclear waste, which accumulates every day in the core of operating reactors and in the immediate vicinity of those plants. Burial is no solution as long as the industry keeps working. California was wise to pass a law that phases out the production of nuclear waste by banning new plants. It's time for other states and other nations to follow suit.

**Lance Gould:** Thank you. Gordon. Paul, Gordon mentioned Germany and how it twice attempted to find a solution to burying waste. Let's talk about Germany. Germany was very invested in nuclear energy. By 1990, 25% of Germany's electric power came from nuclear energy, but the country legislatively mandated 100% phaseout of nuclear power by the end of 2023. And that has actually happened. So how is Germany faring since, and what does this bode for the rest of the world, Paul?

**Dr. Paul Dorfman:** Okay. 2024, 140 terawatt hours: more renewable electricity generated in Germany in the first half of 2024 than ever before. That means 65% of all German electricity generation was renewables. Okay, repeat that 65% of all net electricity generation in Germany: renewables. So generation from fossil fuels is declining. Just 4% of German electricity imported. Of that, 59% was renewable. So basically renewables has killed German nuclear, pushing out coal with carbon. Coal burn has dropped to the lowest level in 60 years, after the nuclear exit. German lignite power has fallen to the lowest since 1963, with hard coal power production has dropped to the lowest since 1955. So at the

same time, Germany, the third largest economy of the world, high per capita income, GDP, low debt to GDP, low inflation, good credit rating. So basically, I mean the take home message is, over the past 20 years, German electricity generation increased from 9% renewables to 65% renewables, fossil fuels fallen from 61% to 38%. That's progress.

**Lance Gould:** Thank you, Paul. I'm getting a note from the producer that we're running over time, so I'm going to ask if both of you can just give a quick, closing statement, as brief as you can. Gordon, let's start with you, just in terms of closing statement and thoughts here.

**Dr. Gordon Edwards:** Well, I think it's important to realize that the nuclear industry has seen they're in bad shape. For the last 25 years their share of electricity production has been falling, and they're looking to grab money that is set aside for climate change. And that's a waste of money. We should be putting that money into the cheapest and fastest alternatives. And those are clearly energy efficiency number one and renewables number two.

**Lance Gould:** Thank you. And Paul.

**Dr. Paul Dorfman:** I was speaking in the UK Parliament with Khan. Afterwards we had supper together. Through an interpreter. He turned to me and he said, if the wind was in the wrong direction, we would have lost Fukushima.

**Lance Gould:** Wow. Well, thank you for both of you. For being here, for enlightening us with your incredible depth of knowledge. And I'm going to turn things back to Alison, the emcee for the event. And thank you very much.

## Panel Three: SONGS:
## Symptomatic of a Nationwide Nuclear Waste Crisis

**Alison St. John:** So the next panel that we have is called "SONGS: Symptomatic of a Nationwide Nuclear Crisis". And we have Thomas Bass is going to be moderating it.

**Dr. Thomas Bass:** I'm Thomas Bass. I'm an author, investigative reporter, sometime professor. I have a book coming out on Fukushima, and all morning we've stared at these photos. You can notice right here, like every other reactor, it's first of all, it's on the ocean. Secondly, look, they've cut away this escarpment. They've placed it lower to the water in order to make it cheaper.

**Dr. Thomas Bass:** We have these canisters here that were designed and put in place by Holtec. I've written on Holtec. I live downwind of Holtec canisters on Cape Cod. The canisters are, of course, inferior to 20 years longevity. You have here SONGS exemplifies every problem that existed, every nuclear reactor in the United States. So this particular panel, panel number three is "SONGS: Symptomatic of a Nationwide Nuclear Waste Crisis".

**Dr. Thomas Bass:** Basically, this is symptomatic of what's going on at all of the reactors in the United States. They're all storing their waste directly next to the reactors. So on panel number three, first of all, Rear Admiral Len Hering. Rear Admiral Herring, for 32 years he was in the military handling nuclear waste. Then I believe you've gone on to the University of San Diego and vice president for business services and administration. Again a public interested citizen handling nuclear waste and concern for the safety of all of us.

**Dr. Thomas Bass:** We have, Gary Headrick. Gary Headrick is known to all of you here as a local hero. He and Laurie Headrick, his wife, co-founded San Clemente Green. This is the rabble rouser and organizer who was responsible for shutting down the San Onofre nuclear reactor. Remarkable job on his part of community organizing and rabble rousing.

**Dr. Thomas Bass:** Paul Gunter is another rabble rouser and hero in this entire story. He organized the Clamshell Alliance.

**Dr. Thomas Bass:** He got his start as a rabble rouser and a protester, organizing the Clamshell Alliance. These two people are very good at organizing things. The Admiral is very good at running things. Paul Gunter, those of us who follow the nuclear energy and nuclear power plants in the United States, he is an astounding resource. He was a director of the reactor watchdog project for the Nuclear Information and Resource.

**Dr. Thomas Bass:** Paul in 2007 joined Beyond Nuclear. I don't know whether any of you are on their mailing list. They're remarkably well informed. Paul is an astounding source of information on nuclear energy. So we have three experts here on these matters of San Onofre, as a local particular example of what's happening all across the United States and in fact, all around the world. So I turn this over to you.

**Paul Gunter:** The fact that this issue has been going now for seven decades without really being addressed, it's always been put on the future for whatever solution gets conjured up. And all through this process, the environmental review of this on site storage has not really been adequately conducted, if at all, really. But you add climate change now to this, and again we find that the whole issue is not being addressed. But what I wanted to really focus on in these few minutes is the fact that there is a very important report that's come out through the investigative arm of Congress. This was published on April 2nd, 2024 through the Government Accountability Office, and it basically points to the fact that the Nuclear Regulatory Commission has not taken on, in its licensing and oversight process the need for factoring in and doing environmental reviews on high level radioactive waste. This is a video that was produced by this report, by the GAO, "Nuclear Power Plants: NRC Should Fully Consider the Potential Effects of Climate Change". And again, this is the GAO. This is not the Clamshell Alliance. This is not Beyond Nuclear. This is a government body informing Congress. (Plays video)

**Paul Gunter:** So again, when we're talking about fully considering climate risks, what we want to make clear is that this is the full nuclear uranium chain that we're talking about. So the power production and the nuclear waste management, those are pieces of it. But this would include abandoned uranium mines, uranium mine tailings. The whole process needs to go through this environmental review and climate change projection that the GAO has now provided us with a very valuable tool. We're already using the GAO report in litigation before the Atomic Safety and Licensing Board again, since this is now a tool that is also available and should be reviewed in Congress, also should apply to the whole fuel cycle as well as as a valuable tool for going before state legislatures.

**Paul Gunter:** (References image of SONGS) But what we haven't seen yet is this. These are vertical storage canisters, and these are horizontal storage canisters. These are much older. So this is the entire independent spent fuel storage installation. But I just want to make sure that we're clear that it's much bigger than just this section here which is the newer section.

**Paul Gunter:** But the GAO reports again that, here we see just how close the Independent Spent Fuel Storage Installation is to the ocean front. And their concern again is that water inundation can damage the cooling system. This is for both the operative cooling system for the reactors. But I also point out parts of the fuel cycle, which includes the uranium mines and other facilities, as well as this close proximity to the ocean. And they also are very concerned about rising sea level, which again, will bring about a corrosive effect to these canisters.

**Paul Gunter:** This is appendix three in the GAO report. It's about nuclear power plant exposure to selected hazards. San Onofre has special recognition in this table. Notice that San Onofre is listed as a high flood hazard level. Not only that, but the wildfire potential level is listed as high to very high. Now, I think both of these need to have a Freedom of Information Act filed to look at what the government knows about wildfire potential levels at San Onofre. But this provides another valuable tool for the GAO report in your local work for the San Onofre plant.

**Paul Gunter:** So these are just some pulled quotes that I think that are important. You know, we're concerned with the licensing and license renewal. I encourage you to read this report. We can't really go through it in the limited time that we have here right now. But at every level of the NRC involvement in its licensing and oversight, we see that NRC does not use climate projection data to identify and assess risk as part of the safety review, and I would add environmental review for its probabilistic risk assessment as it conducts its initial licensing process. That would be for both the operating reactors and the licensing of new canisters, and as well as license renewal. The US Nuclear Regulatory Commission has raised the licensing now up to 40 years per licensing period. And the relicensing can be done indefinitely. So they've opened it up pretty wide. And again, the inspections process right now don't include an assessment of future climate projections.

**Paul Gunter:** There are just three recommendations that come out of the GAO report that I think are worth noting. These are really executive actions for the NRC commissioner to do but they're

recommending that NRC assess its oversight process and for potential increased risks to plant operations. And that would be both the operating reactors and their independent spent fuel storage installations. Recommendation two is for executive action to look at the gaps that we understand are in the oversight and licensing process. And then recommendation three is to develop and finalize guidance on incorporating climate projection data into these relevant processes, including what sources of climate projection data are to be used and when and how it's used for climate projections. So these are instructions to both the legislative groups and for communities to raise this both at a federal level and a state level. So thank you very much.

**Dr. Thomas Bass:** Well, Paul, thank you very much. One immediate question, and then we'll move on.

**Audience Comment:** Dr. Peter Anderson, I'm author of the Sierra Club Nuclear Waste Policy and a member of the Samuel Lawrence Foundation and Sierra Club. I just want to make one statement. We've heard a lot of great suggestions, but there's a lot of naysayers out there. So here's my suggestion. We work at the local level. We work at the state level. We work at the federal level. We work with the legislature. We work with the administrative branches. We work with the judiciary for a lot of speakers say, oh, that won't work. We need an all hands on deck, all approach policy to try every one of these outlets. And I urge us to continue to pursue every possible option in dealing with this problem that has been so clearly outlined today.

**Dr. Thomas Bass:** Certainly a worthy comment. Let's move on to Gary Headrick for just a few minutes here. Once again, San Clemente Green.

**Gary Headrick:** I'm going to rely on the skills I learned in addressing city councils at three minute intervals here. Maybe it'll go to seven, but I'll try to make it quick. So you've noticed the SOS San Onofre Syndrome movie that's out? A lot of that is about our story, that I don't have to go into any detail about, because it's 12 years of recording the activist role in trying to get the plant shut down. And then what have we done since then? So I just want to give you the basic background where Laurie and I started San Clemente Green to create a sustainability action plan, and it was in 2007, by 2010, we had completed it, and we had developed a really nice working relationship with the city. So happens that 2010 is when people that worked at the power plant started connecting with us, because they are afraid of retaliation from management for reporting safety violations. So we protected their identities. We started

approaching city councils and got just shocked that they wouldn't listen to us. It wasn't their jurisdiction. It wasn't their responsibility. They said, talk to the NRC. The NRC says no worries. You know we got it handled. It's been a wild roller coaster ride ever since.

**Gary Headrick:** And, you know, we heard a lot talked today about We The People. I kind of feel like that's where Laurie and I fit in. We are part of the we the people that is all of us. But we don't have any special credentials or capabilities. We just have the desire to protect our families, our community and the future generations. And we're committed to this to the point where there is no going back. We have to follow through.

**Gary Headrick:** We have the wrong kind of canisters, and I'll show you pictures. We need to replace those canisters before they fail. Second of all, this is rolling stewardship. We have to work together. We have to pass this on through generational efforts. And third of all is a little brief trailer from the movie I want you to see, because it'll say a lot more than I can.

**Gary Headrick:** (Referencing slides) But first, I want to take the time to at least read through this list, because this is the crux of the matter. We have the wrong canisters. They have to be replaced. It's going to be dangerous. It's going to be necessary. So here we have the thick walls versus thin canisters. Check the empty column over here. The thick casks are what's used virtually everywhere else in the world. But for some reason, well, the reason was because the government said they were going to pick it up in 1998. So now we have thin temporary canisters that won't last long enough for us to solve the problem permanently. The thick cask won't crack. We can repair and replace their seals. We can inspect them inside and out. There's a monitor system that prevents leaks. It's certified, stored in concrete buildings, gamma and neutron protection, transportable without an additional cask. So there's so many advantages. And it's so unfortunate that we didn't use the proper casks in the first place.

**Gary Headrick:** So now we're playing backup, trying to get back to where it's safe. So these are recent pictures. Well, you know, a few years old now, 2019. These are canisters that Holtec loaded into these silos, and they're already showing serious amounts of damage. And I've asked several times, "are they going to repair these?" And they say, "well, they're not to the point where they need to be repaired yet." And how many of them are like this? So there's another one. The next slide is how the same canister got gouged on the download into the silo. They say that's not a deep enough gouge to worry about, but that

sure looks bad to me. And we live in a tsunami hazard zone. It's obvious we have signs posted all over town. This is what's happened since 2013. The above picture shows how much sand used to be there with rising sea levels. Now our trains are getting hit by waves. This is what the condition looks like right at the tsunami wall. The tsunami wall ends where all that iron structure begins. And it's very vulnerable. It's obvious to anyone. And this is how Edison likes to represent it. The original graph underneath the photograph is what Edison provided.

**Gary Headrick:** (Referencing images) And it looks like the water level is well below the canisters. If you look at the photograph you can see where the actual water level is. And if you draw the line across there, then the canisters are submerged. Although they're protected, they're not really in the water, but they could be eventually because that's what water does. Here's a close up of the tsunami wall condition. And the next one is the overall view. They even had to warn people from walking near it. And this is me trying to give a little human scale to what it's like when the high tides are gone. And that's high tide with 2 to 3 foot waves. Otherwise, I wouldn't have been there.

**Gary Headrick:** And this is what we hope will be the eventual solution. In Switzerland, there's a place called Zwilag, and they have stored all their nuclear waste in these thick casks that are inside this robust building. Protected from terrorism, storms, airplane crashes, you name it. This is what we need and we need to get started soon because these canisters are on a short time fuse. This is a hot cell or dry transfer facility, which has been mentioned earlier today. And that allows us to put a canister into a protected environment, work on it with robotics and that allows us to empty the contents of a damaged canister and put it into a new one. And that's what we don't have. We have no plan. And that's what Larry Agran was saying. We need a plan, and this is part of it.

**Gary Headrick:** (Plays Video)

**Dr. Thomas Bass:** Gary. Thank you. Thank you very much. So a question or two.

**Audience Comment:** This is kind of a personal thing. During my eviction battle with the city council and city of San Diego, I took fliers for SOS. And I gave them to our city council reps, the mayor's office, I think our assembly. I also emailed Congressman Peters. No action has been taken. So if all of you could do

simple things like contact your local representatives, contact your local schools, contact your local hospitals, to view this. I'm just one little person. But if we get more of that, you know, and they need to see this.

**Dr. Thomas Bass:** One more question.

**Audience Comment:** Gary. I'm just curious given the reluctance of Sempra to switch over from the canisters to the new casks, which I actually did some calcs on for Bart a couple of years ago. Is there anybody in this room that might be able to shed some light on the potential for asking that company, I forget their name, this the company with an installation in Switzerland, if they might be able to design a cask that was a very similar to the ones that they have, but was able to actually and I know the proximity of the rods in the existing cast may be closer than they would be in the new casks, but if the proximity and the conditions for each rod in the existing casks isn't per se the issue, then might it not be possible to design one of the newer casks that could accept the entire canister?

**Dr. Thomas Bass:** This is the Russian doll solution, where you put one of these canisters inside another canister. I think, Gary, what do you think?

**Gary Headrick:** Yeah, that's a good question for someone else that, you know, could answer it better, but I could fill you in a little bit. The canisters as they are today are convectively cooled, so they have to have air circulating around them. And if they don't, they'll overheat. So the longest you can put one in another canister is 30 days. And there's still more research to be done. But, you know, we're in this institution of education and that's where the answers are going to come from. I hope people will hear this today and think, I want to try to be part of that solution. I want to figure out if we can put a canister in a different kind of container or something that we haven't thought of yet, we're in the building of innovation. Let's make it happen.

**Dr. Thomas Bass:** Thank you. Admiral Herring is once again going to address us.

**Admiral Len Hering:** I don't know how you follow those two, but I've been asked to do the same.

**Admiral Len Hering:** It disturbs me. And I don't mean to pick you out, but it disturbs me that a young high school student does not know Fukushima. Do you know what Chernobyl was? (Addressing audience member) Okay. The fact that you don't know what Fukushima is is distressing, because it is significantly greater because it was an accident that didn't happen in the same fashion that everybody focused on Chernobyl. It was a meteorological or oceanographic event that caused exactly what we're talking about. Exactly the same thing. And we have to figure out how to get there from here. I was the Vice President for USD for a while and started getting involved in sustainability. I installed the largest photovoltaic system of any private university in the country at USD. I took the knowledge that I learned in the Navy, and I brought it to USD to help them try to get there from here. The energy cycle is the most important cycle for the future. However, I then left the USD and I became the President of the Center for Sustainable Energy, the largest non-profit organization in California focused specifically on sustainable energy for the future.

**Admiral Len Hering:** And I will tell you that nothing was more distressing in that job than battling with the public utility, whether it be the commissions or the utilities themselves. The effort and entities that Mark was talking about are the reason why that solution set will encounter problems into the future. You will never get there by 2030, because the entities involved will lose all profit margins from histories going forward. There is no profit for them in the same fashion, and the investments that they've made to date will virtually be sold out before their life expectancy in the process. Therefore, the money spent will never be able to be returned. So there is an issue here that we must address in a different fashion. I too am a member of the American College of National Security Leaders, and have been involved in that organization for about five years. It's 60 of US flag officers, ambassadors and others who are advising the Department of Defense and the State Department on issues regarding security and other items. One of them happened to be climate change and the impacts of climate change on security. I am also a senior member of the Center for Climate and National Security. I have been working very, very hard and this year, the Department of Defense has released its first climate change adaptation plan going forward, recognizing that regardless of what you want to call it, the issue is a security concern. I don't care if you want to call it a security concern from a national perspective or a citizen's perspective. What we are talking about here is the security of you all. So it really doesn't make any difference how. But the fact is, is that those individuals who are responsible are not taking the actions necessary to ensure that security is, in fact, protected.

**Admiral Len Hering:** So everything that's been pointed out here, whether it be from the climate security groups or the engineers who have talked about the efforts, there's a reason why. And we need to ask the question, why did that happen? Why did Holtec win the contract when there were six other proven contractors who could have provided long term storage capacity for the materials after they knew that Yucca Mountain was shutting down. The conversation on Yucca Mountain has been going on since 2012. So they knew when all this stuff was going on that they were not going to be able to move this material in the 17 year time frame that the canister was designed to provide. And there were contractors across the globe who have taken on the responsibility of ensuring that the security of their citizens are, in fact, taken care of.

**Admiral Len Hering:** The model that you saw right there, a 10.5in compared to 5/8 inch canister, I don't care if they expected it to be a 20 year cycle, and the canister was four inches thick. 5/8 of an inch thick canister. That's what we are dealing with, and the conditions and issues that we have to understand have much greater concern than have ever been in this entire process. So whether you call it climate change or you call it anything else, if any one of the situations that Gary has brought up or Mark brought up or anybody else when it comes to what could potentially happen to compromise this decision is something that needs to be addressed and it needs to be addressed now. The NRC is responsible from a federal perspective to the Congress, who has oversight of the NRC, for the actions responsible by legislation that provide the NRC its authorities. So where does it come from again? We The People, put the people in power who are responsible for making sure that that oversight is in fact being applied to the organization that has the legislative authority to impact and impose restriction on industry. So the only other concern that I have, and Greg, I think brought it up this morning, is we have a piece of legislation that basically eliminates the power company from having the responsibility post production of energies.

**Admiral Len Hering:** The only thing that is of great concern for me when all of this was first discussed, somebody from the federal authority said, "Here's what happens: you revoke the law, you make the industry responsible for the waste that it has produced, who has ultimately passed that responsibility to the contractor, Holtec in this case, and the very next day, Holtec declares bankruptcy. Done." That's where it is. We can't do one without the other and address the issues that are present without really having a plan that includes the consequences. I worked in the Joint Staff for three years, I was the Pacific desk officer, I actually was the officer responsible for the issues with North Korea and their nuclear power plant when that was all going on. So I watched what happens on a larger scale when we're talking about those issues. But at the same time, we spent a tremendous amount of time strategically planning for events.

**Admiral Len Hering:** And as you said, hope is no course of action. There is never an opportunity where a military person will come to you and says, "well, we hope that that is not a course of action that we can expect." That individual is dismissed from the plan, and we go through and create the courses of action that we need to address in order to make sure that the strategic plan is, in fact, prepared and that operational planning and then the other planning all happens. None of that is happening here. None of it. So Larry's proposal, I think, starts that process. Somebody's got to start the planning process. It may not be the solution, but at least it gets people focused. And if nothing happens after a year, then you start holding people accountable for what is and what isn't, but at least we've addressed on a planning perspective what's necessary. And then they can go forward and start working the other issues. So that's kind of where we are. And I think it's like that across the country. It doesn't make any difference where it is, but we need to figure out how to get from point A to point B and hold those individuals accountable.

**Audience Comment:** ""

**Admiral Len Hering:** So the question is, each of the particular agencies are responsible, but it doesn't mean that they can be held accountable. And do you have the opportunity, say, with Holtec and the way business was done, do you have the ability to hold those individuals responsible and accountable for what you have and where it all comes from? And I would tell you the answer is I don't know. Because the truth of the matter is, Holtec is probably one of the most waived and penalized organizations under contract by the federal government or the energy utility that we've ever seen. And we went back to the NRC under the FOIA act and asked for all of those waivers. We still have not received them all. What they did is gave us the waivers only from SONGS from the day of decommissioning, not from across the country, the number of violations or anything else that Holtec has been responsible for. We've never had the FOIA request answered by any of the individuals from the citizens group who have asked the question, how is it that this particular company owns all of the contracts in the United States? And again, why was Holtec allowed to continue its effort past 2012, knowing that Yucca mountain was going to be secured. I don't know, but Congressman Levin is trying to put together a portion of the organization at the NRC that deals specifically with the decommissioning, because there is no one at the NRC who really are experts with the decommissioning process. They're experts on production. They know how to operate the plant, but there's no one there who is truly controlling the decommissioning process. So what we don't have is we don't have an organization who can make regulation. The same body of individuals who are running the power and production are the same body of individuals right now who are telling you how to store nuclear material, and I don't believe that the expertise is there.

**Audience Comment:** My question is, is there any conversation with UCSD or throughout the Samuel Lawrence Foundation to share this with the engineering school here, with the public policy on engineering with every city council in Southern California.

**Rita Macdonald:** Hi, I'm Rita Macdonald, the Chief Operating Officer of the Samuel Lawrence Foundation. As part of our outreach for this symposium, we invited every US senator, every congressional member in San Diego, Orange and LA County, every supervisor in San Diego County. Every city council person and their staff in San Diego County and Orange County. In addition, one of our board members contacted on our behalf the chancellor of the university. The chancellor of the university sent out invites to the engineering school. And so I think we kind of covered that. And we're going to continue to follow up.

**Admiral Len Hering:** I don't think the Samuel Lawrence Foundation is going to even let that be the bottom. And hopefully many of you reach out to those individuals, but bringing the engineering and the oceanographic and meteorological conduct together is vital to what we do going forward. There's no doubt about it.

**Audience Comment:** I'm Leslie Ewing, I'm a retired engineer and we love to design things. We love to do stuff as engineers. Rather than have them come to a symposium, why not have a challenge throughout the engineering communities in the country of how to better design storage of nuclear fuel? I mean, give them a question. Don't give them a policy you want done. Thank you.

**Dr. Thomas Bass:** Thank you. Leslie worked for the Coastal Commission for 35 plus years.

**Admiral Len Hering:** The only thing we need to rely upon that question is, the folks who are in this room and know where the money comes from, you get the grant, and that will happen. I guarantee you, because again, we asked for portions of the system to work with us on the task force, and the first thing they asked is, where does the money come from? How do we fund what those efforts are? I'm sorry to say that I get it. I was the business officer at USD, Vice President for business services and administration,

I get it. I think that's what we need to do is figure out a way to get there from here, because there are some amazing engineering and physics folks who could potentially do this including taking a look at the systems that already are in place, which would be the best one for us to go forward. And I think that's where we have to go.

**Audience Comment:** So this is just a question for all the people among the panel. So I understand that a lot of these problems have been based on mismanagement, and the regulatory organizations are basically inept at their certain duties to regulate this. But in the future, what is your opinion on the role nuclear energy has in phasing out fossil fueled energy sources?

**Paul Gunter:** Well, I think that we have to first look at the history of nuclear power to project what to anticipate. And going back for me, it goes back to the generation two nuclear power plants like San Onofre, where almost half of the applications that went in were never completed because of the loss of control of the cost of nuclear power and the inability to project how long it would take to complete them. That then bled into generation three where applications for 34 units that came out of the 2005 Energy Policy Act, where the government pumped billions of dollars into this nuclear renaissance, only four broke ground of the 30, 34, 35, and only two were completed. The Vogtle plant was projected at $14 billion for two units, and it's actually going to approach closer to $40 billion. And we've got CEOs and senior managers from some of those utilities that wound up doing time in federal prison for wire fraud. So again, the window of opportunity on addressing climate change is closing the current policy. Now, before the US Nuclear Regulatory Commission is to look at the role that nuclear power plays in controlling carbon emissions to climate. But they don't look at any of the pieces of climate change impacts on nuclear power plant operations. That's only half the situation.

**Gary Headrick:** Just real quickly, I want to thank you for being here and asking that question. And welcome to Rolling Stewardship.

**Admiral Len Hering:** And if we recognize that that be the case, if I had the keys to the castle to answer your question, I would put together another Manhattan project and figure out how to get there from here. If this country was truly focused on its future, it did so in the Second World War for its preservation of the world's societies. It should do so now on energy. And if nuclear power falls off the scale, then

nuclear power falls off the scale. And until we do that kind of study, I honestly don't believe we're going to get there.

**Alison St. John:** Okay. So thank you very much. I think we're going to have to wrap it up there. And Thomas is going to be moderating the next panel. Since he didn't introduce himself, he did actually write a book called *The Return to Fukushima* so look for Thomas Bass' book coming out this fall.

## Virtual Presentation with Dr. Amory Lovins

**Dr. Amory Lovins:** Hi, I'm Amory Lovins, calling from my passive solar banana farm, near Aspen. It was cheaper to build that way 42 years ago. I'd like to offer a presentation which may overlap a bit with Mark's. We have offices just down the hall at Stanford where I teach, as he does in civil and environmental engineering. But I come at it a little different way. A widespread bipartisan view holds that more nuclear power can help to reduce climate change. I'm going to show the opposite is true because nuclear power is too costly and slow, and it also has no business case or operational needs, so we needn't pay extra to keep generating more nuclear waste. Michael Schneider who produces the Essential World Nuclear Industry Status Report has kindly shared 11 graphs on nuclear power's global status and prospects. The nuclear share of world electricity generation. The red line on the left has fallen by nearly half to 9%. Its output in purple has stagnated. You can see on the right the output growth is more than all in China. The yellow bars output from the rest of the world has fallen back to the level of the mid 1990s. World nuclear capacity in red is about 1% above its previous peak in 2006, because the fewer but newer reactors tend to be larger. In the past 20 years, two more reactors have closed in brown than were built and connected to the grid in blue, but without China in yellow, which has started up 49 reactors and closed none, the world has actually lost 51 net reactors over the past 20 years.

**Dr. Amory Lovins:** Those now under construction are only a fourth as many as they were in 1979. And the projects marked in gold, 1 in 9 did not actually get finished. Of the 60 reactors still under construction, 40% are in China, 50% are in China or India. And all of the past five years, 35 nuclear construction starts worldwide are centrally planned. 22 in China and the other 13 are geopolitically motivated Russian projects in several countries. Last year, China conducted one nuclear gigawatt, 1,000,000,000W to the grid. They also connected to the grid 286GW of solar and wind power, because those are faster and half the cost. China's nuclear output was surpassed by Chinese wind power since

2012 and by Chinese solar power since 2022, and China's nuclear investment is a tiny fraction of its renewable investment. Where is the global nuclear renaissance? Well, construction starts are sparse six last year, five of them in China and four this year through May, two of them in China. Most reactors were built, as you can see, decades ago, and meant to last 30 or 40 years. Their average age is 43 years in the US, 32 in the world.

**Dr. Amory Lovins:** The reactors closed in the past five years, averaged 43 years old. Old reactors, like old cars, tend to break more and cost more to fix. The International Atomic Energy Agency expects an average of ten closures per year during 2018 to 50. The startups in the past decade have averaged only 6.7 per year. Assuming 40 year average life or any extensions already approved, global nuclear capacity should therefore shrink in all but three future years as closures outnumber new starts. So it's hard to imagine nuclear output even holding steady, let alone rising. The second biggest nuclear fleet in France averages 39 years old. Its recent poor performance crimped European electricity more than Putin's war and more than Germany's nuclear phase out. The national utility can't even afford to modernize its 56 reactors, let alone replace or augment them. Paul earlier gave you some German numbers, the biggest economy to abandon nuclear power, number three in the world and Germany simultaneously slashed fossil fuel generation in red as renewables in green soared to 53% share. And electric efficiency also rose 51%. Likewise, in Japan, efficiency and renewables more than offset the major nuclear shutdowns after Fukushima Daiichi. Globally, nuclear power output in magenta has stagnated at just one third. The output of renewables in green, which keeps soaring and should pass coal next year. The world is set to add more renewable capacity in five years than in the past century.

**Dr. Amory Lovins:** Renewables made 30% of global electricity last year and the International Energy Agency predicts 42% renewables four years from now, including 25% from solar and wind. So nuclear just shrank to 9%. Revolution already happened. Sorry if you missed it. The world's exponential growth of wind, solar, electric vehicles and batteries has made nuclear power irrelevant. In its best years, it adds as much output all year as renewables add every few days. The United States has similar patterns where fair competition is allowed. Renewables and efficiency displace nuclear output within typically a year or two after a nuclear plant closure. This familiar Bloomberg history of unsubsidized levelized wholesale electricity costs shows why renewables win, as columnist Tom Friedman says, "the more renewables we buy, the cheaper they get. So we buy more, so they get cheaper." Adding grid integration costs for all competitors would actually widen renewables cost advantage. That's because fossil and nuclear plants tend to have bigger, longer, more abrupt and far less predictable forced outages than solar and wind power, especially in portfolios, and thus need more and costlier backup than renewables for the same

reliability. The International Energy Agency estimates that 96% of new solar and onshore wind power last year was cheaper than building new coal or gas power, and about three quarters of the new solar and onshore wind beat just the operating costs of existing fossil fuel plants.

**Dr. Amory Lovins:** Bloomberg confirmed that the cheapest way to meet a flat load is now solar or wind power plus backup, which can be demand side or storage, or renewable or fueled for accommodation. Costs are flat for fossil fuel power. They're rising for nuclear, but they keep falling for renewables and storage. Batteries are now getting more investment, and adding more capacity than nuclear is. To give you an idea of how fast renewables can go in just two years. Vietnam added over 16GW of solar power. Nine gigawatts of it on 100,000 rooftops or the like. That's equivalent to building half the nation's coal plants in a year. And about 72% of those panels were installed just in the last month, in December, mostly in the last week of December. The distribution grids are still racing to catch up. Vietnam's communists set a world speed record in privately financed solar capitalism. A similar revolution is emerging from China's whole county rooftop solar program. Rooftop photovoltaics were not a thing in 2017. Four years later, they were 40% of total and 61% of new Chinese solar power. China then had 27 rooftop gigawatts, growing eight gigawatts a year. Now, rooftop PVS are 30% of the total world PV capacity. They're half of all solar investment. They're heading for 95GW by next year. So very fast when you build hundreds of millions of units. But there's an even more formidable competitor.

**Dr. Amory Lovins:** In the past 48 years, saved energy, about two thirds due to smarter technologies, has dropped US primary energy use by 64% with immense cumulative savings. Renewables, meanwhile, nearly tripled, but with 26 times less cumulative output. Renewables get virtually all the headlines because they're visible While energy is invisible and the energy you don't use is almost unimaginable. Yet saved energy is half of the world's historic decarbonization and at least half of future decarbonization. Those past savings just scratched the surface. The integrative design practice I teach at Stanford makes the end use efficiency resource several fold bigger, yet cheaper. It could quintuple global end use efficiency by about 2060, or triple it by about 2040, as documented here. And that end use efficiency does not include the further 2 or 3 fold upstream energy savings from electrification, with primary renewables saving nearly $5 trillion of annual waste inherent in the fossil fuel system, that's almost 5% of world GDP. Pure waste. But even without much integrative design, US electricity use could shrink by a quarter by 2050, despite all electric autos and a 2.6 fold bigger GDP. This quadrupled electric end use efficiency would save kilowatt hours for a 10th or US retail price. So much larger savings than 4X would still save money.

**Dr. Amory Lovins:** How should we compare different ways to power the economy? Well, we built coal fired power plants by counting cost, but not carbon. Nuclear power is promoted by counting carbon, but not cost. But to protect the climate, we must save the most carbon at the least cost and in the least time. Counting all three variables carbon and cost and time. Costly or slow options save less carbon per dollar and less carbon per year than cheaper or faster options, so even a lower no carbon option that is too costly or too slow will reduce and retard achievable climate protection. Many analysts ignore common sense comparisons of cost and speed, leading to results akin to arguing that since people are hungry, hunger is urgent and caviar and rice are both food. Therefore, both caviar and rice are vital to reducing hunger, since in reality money and time are both limited. Our priorities in feeding people or in providing energy services must be informed by relative cost and speed. Lower cost saves more carbon per dollar, faster deployment saves more carbon per year, and we need both of those outcomes. Far from offering a solution, the world nuclear industry is dying of an incurable attack of market forces. In the past 18 years, 12 US reactors retired. Three finally started up at astronomical cost. Two closures are pending and one firm that's never run a reactor hoping to restart a closed one to reap huge subsidies. However, the economic principle of opportunity cost means you cannot spend the same money on two different things at the same time.

**Dr. Amory Lovins:** Each purchase forgoes other purchases. So buying nuclear power displaces efficiency and renewables, and vice versa. So nuclear owners and allies strive to beat fossil fuels and to suppress renewables. Yet despite subsidies that rival construction cost, most US reactors are uneconomic just to operate. So many were closing that nearly two decades ago, they got $15.5 billion in bailouts from pliant or sometimes corrupt state legislators and federal nuclear enthusiasts. The manyfold larger new federal energy nuclear subsidies added in 2021 and two, Tim Judson calculates a total of $133 billion. That's enough to install nearly 100GW of solar and wind power at recent Texas prices. Worldwide, nearly all new reactors are funded compulsorily by taxpayers or customers because few private investors will accept a high financial risk. And many new reactors are also shielded from competition by guaranteed sales and guaranteed long term prices. Here's how those prodigious new federal grants and financings bailed out the 90% of US nuclear plants that were running in the red in 2020 and suddenly turned green. Well, no wonder the nuclear industry has quietly changed its business model from producing products to investing in PR and lobbying to harvest new subsidies. But we should all, especially conservatives, reject the mushy and muddled political mantra that climate urgency needs all of the above, flying every option to satisfy every moneyed constituency. Because supposedly in a climate emergency, surely we need every possible solution.

**Dr. Amory Lovins:** Actually, no. The more urgent you think climate change is, the more vital it is to buy cheap, fast sure options instead of costly, slow, speculative ones. That's the only way to save the most carbon per dollar and per year. Any other strategy makes climate change worse than it should have been. So when some official says "we support all of the above, we're not picking and backing winners." Just remember Peter Bradford's apt retort. He said, "no, we're not picking and backing winners. They don't need it. We're picking and backing losers." And remember Senator Grassley's wonderful remark that on closer examination, many in DC who claim to be in favor of all of the above are actually in favor of none of the above and all of the below. Enthusiasts claim that substituting various kinds of small modular reactors will achieve competitive costs, but that takes magical thinking and today's reactors are the wrong competitor. Early SMRs would produce electricity at well above probably at least twice the cost of today's light water reactors, which Lazard found make electricity about 2 to 8 times costlier than modern renewables do, or about 5 or 10 times costlier than on site efficiency. But by the time SMRs, if successful, could begin mass production, their carbon free rivals are set to get another two fold cheaper based on observed learning curves, which nuclear power has never demonstrated.

**Dr. Amory Lovins:** So just do the math. Two times 2 to 8 times two means mass production must make SMRs 8 to 32 times cheaper, or 24 times using Bloomberg cost figures. Neither range is plausible. SMRs cannot catch up because small modular renewables, which do scale down well, have decades head start and exploiting their own formidable economies of scaling and learning. Novel reactor designs or fuel cycles offer no escape because even if the minor nuclear part of the prohibitive capital cost of today's reactors were free, the non-nuclear remainder would still be about 2 to 6 times too costly. Nor could SMRs be developed and scaled before the US grid is decarbonised without them. SMRs would only divert investment, attention, talent and time from off the shelf popular, benign, competing technologies that have already proven rapidly scalable and win more than $1 trillion of private investment each year. Substituting costly, slow SMRs would thus make climate change worse and proliferation vastly worse. I'm astounded that the Department of Defense is letting the Department of Energy undercut its national security mission by promoting the most proliferative kinds of fuel cycles that our government has just spent decades trying to prevent. SMRs are off to a rocky start. The world's only four modules in China and Russia were slow, costly and underperforming. Electricité de France scrapped its SMR program and is starting over. Three US flagship start ups have stumbled. Bill Gates estimates his proposed Wyoming sodium fast reactor, a type that's failed in all main nuclear nations, could cost $10 billion.

**Dr. Amory Lovins:** Like many SMR designs, its fuel is both unavailable and directly weapons usable. The potential safety of the over 80 SMR designs and their development varies and is often unknown. Wastes

are generally similar or worse costs are much higher. Nuclear power also offers no benefits for grid reliability or resilience. Justifying special treatment. In fact, its inflexibility and ungraceful failures complicate modern grid operations. Traditional so-called baseload thermal plants are an antique honorific, but they're no longer needed or economic, as we'll see in a minute. And as Doug Parr of Greenpeace says, "nuclear power can't bridge the gap between anything and anything. It's too slow, it's too expensive. It's a massive distraction." Now, the gigawatt scale of the state of South Australia should complete its transition to 100% solar and wind generation. That's 100% variable renewables in the next few years. Here's what that looks like monthly over the past 24 years. Solar in yellow, wind in green have already displaced essentially all the coal, the imports in purple, and most of the gas in light and dark brown with very successful and lucrative stabilization by big batteries. The highest renewable oversupply was 264% of peak demand. Last October wind and solar met 87% of the state's total electricity needs annually. It's about three quarters now. Stability and economics have been excellent, but those big batteries are not the only option.

**Dr. Amory Lovins:** To keep the grid reliable while it becomes renewable, we can use not just one grid flexibility resource, bulk storage in magenta, but about ten sketched here conceptually in order of increasing costs. Your actual costs will vary, but bulk storage comes last, not first. So we needn't wait for a storage miracle. And the market isn't waiting. Indeed, though, big batteries can work great and make money, we generally don't need them because bigger and cheaper options. Further to the left of this chart are ample. At the far left, Negawatts and the second box, Flex Watts are both about three times bigger than had been thought. Just integrating parked electric vehicles into the grids is an immense emergent resource. Add up this carbon free portfolio of grid stabilization resources and bulk electricity storage is not needed for a modern renewable power grid. Such grids, more numerous moving parts and more variable output do require good forecasting tools and more care, attention and thoughtfulness. But that's a solvable and solved problem, not an insuperable obstacle. And yet, we're still told that only coal, gas and nuclear plants can keep the lights on because they're 24 seven, while wind power and PVS are variable and hence supposedly unreliable. But variable does not mean unpredictable. Here's how accurately the French grid operator in a stormy winter month a decade ago, forecast a day ahead the actual output of the country's wind farms, they would be very pleased to forecast demand that accurately, and forecasting has since improved so much that East Danish wind operators bid day ahead wind power into the grids hourly auction just as reliably as fossil fuel generators do.

**Dr. Amory Lovins:** Indeed, we built the grid because no generator is 24 over seven. Giant plants fail to losing 1,000,000,000W in milliseconds, often abruptly, often for weeks or months. So grids manage this

intermittence by backing up failed plants with working plants and in exactly the same way, but often at lower cost grids can manage that the very predictable variability of solar and wind, by backing up those variable renewables with a portfolio of other renewables, all forecasted, integrated and diversified by type and by location. So in Texas, whose grid has no big hydro dams and is only 1% interconnected to the rest of the country, a 2050 summer week of expected loads can get much smaller and less peaky with efficient use. Then we can make 86% of that annual electricity with wind and photovoltaics, and 14% from dispatchable renewables, geothermal, small hydro, solar, thermal, electric burning, AG and municipal and industrial wastes burning feedlot, biogas and existing gas turbines burning obsolete energy studies. So then you've got 100% renewable supply, but it's not a great match to the dashed line, the load. So to match them up, we can put surplus electricity into two kinds of distributed storage that are worth buying anyway, ice storage, air conditioning and smart charging of electric autos and then recover that distributed storage when needed. Fill the last gaps with unobtrusively flexible demand. Then you're 100% renewable every hour of the year, with only 5% of the annual output from renewables left over to decarbonize other sectors. So the economics should be excellent even at today's market prices. And some great operators already do such choreography Today, Scotland is nearly 200% Renewably powered. Denmark's closing in on 100, Germany about 55 already. They and some other European countries with modest or no hydropower, even out on the end of the European grid, are meeting about half to three fourths or more of their annual electricity needs from renewables, adding no bulk storage and they're getting superior and rising reliability for Denmark and Germany. It's five times as good as ours. The 99.999% reliable former East German utility 50Hz was 72% Renewably powered last year, targeting 100% by 2032. So, as my colleague Clay Stringer says, "the operators have learned to run these grids the way a conductor leads the symphony orchestra. No instrument plays all the time, but the ensemble continuously makes beautiful music." So it's time to look up. Now notice our neighborhood star, pay attention, except its enormous daily energy gifts, and get to work on building durable prosperity and security in energy and everything else for all forever. Thank you.

## Panel Four: Coastal Dynamics of Nuclear Waste

**Dr. Thomas Bass:** Panel number four is on the coastal dynamics of nuclear waste. We've heard an astounding amount of information presented so far, but what we have yet to hear about is, in fact, what is going to happen to the water on that coastline, the nuclear storage there. There are two possibilities. They can either start corroding and leaking into the ocean, or they could potentially even explode, then it becomes airborne. The panel is going to consist of James Day, Bob Richmond, and Kim McCoy.

**Dr. Thomas Bass:** James Day is a professor in the geosciences at the Scripps Institution of Oceanography, which is hosting this event at the moment. He's a specialist in rocks, banging on rocks, rock formation, cosmos, formation of planets, the evolution of the modern Earth system. And you might wonder what the deuce that has to do with what we're talking about today. But as you recall, deep storage has been a subject. Where are we supposed to store this nuclear waste? Well, a lot of it involves, potentially rocks and going underground. So, that's why James Day has been summoned here. He's going to talk about that. Our next speaker is going to be Bob Richmond. Richmond is a research professor and director of the Koalu Marine Laboratory at the University of Hawaii in Manoa, and he's a marine biologist. He's also a particular interest for us here today because he's been advising, on the expert scientific panel advising the Pacific island nations who have been opposing the release of water from Fukushima. So he's spent a lot of time studying Fukushima. He even spent two years living on Enewetak, studying the results of the bikini and other explosions at the end of the Second World War. He's an expert in marine currents and following what's going to happen to that coastline should those systems fail.

**Dr. Thomas Bass:** And then finally, we have our third speaker here is Kim McCoy. And I'm supposed to hold up his remarkable book here, which I understand is the bible of surfers. It's called *Waves and Beaches*. He's the co-author and is single author of the latest two editions of *Waves and Beaches*, published by Patagonia. Mccoy, is also an expert in sensors and sensing technology, and actually keeping track of what happens to waves and beaches, and has a huge amount of experience in leading expeditions and keeping track of sensors and so on.

**Dr. James Day:** Hello. Good afternoon everyone. I'm going to talk about some of the geological aspects that have sort of been touched on, but somewhat overlooked in how we might store nuclear byproducts. I just want to remind you all, hopefully, you all know that the radioactive isotopes of elements like uranium 235 are actually formed during a process called stellar nucleosynthesis in stars. If you look at this plot just here on the right hand side, you'll see everything beyond iron has this negative slope in this nucleon binding energy. What that basically means is the only way to produce them is by stellar explosions. So these are natural products just to make sure everyone's completely clear on that. They follow a neutron rich pathway making some unstable. And that's why uranium 238 and 235 are unstable. We refer to these as radioisotopes, radionuclides, radioactive nuclides. And there are over 800 known. And they typically dissipate excess energy by spontaneously emitting radiation. So there's nothing new there. Uranium and thorium can undergo radioactive decay by alpha decay. That's really the loss of helium atoms. And for those of you who don't know, uranium 238, which everyone calls depleted uranium, is not, in fact, depleted. It is undergoing radioactive decay. Its radioactive half life is about the

age of the Earth, 4.5 billion years. Uranium 235 has a half life of 700 million years. So since it was first incorporated into the Earth, it's undergone six and a half half lives.

**Dr. James Day:** Most geochemists, like myself, would consider that type of isotope to be largely extinct. So we're still using it today to fuel our economy. Uranium 235 is a fissile element. That means it can be broken up by neutrons bombarding it, and plutonium 239 is exactly the same. Plutonium 239 is produced from neutrons being bombarded into uranium 238, and it has a half life of 21,000 years. This is what makes it so potent. They liberate huge amounts of energy. So typical decay schemes like this uranium 238 decay scheme. This is known as a radioactive decay chain. Uranium 238 decays by alpha decay, and then a whole series of beta and alpha decays, ultimately to lead 206. If you let uranium 235 do the same thing, it would decay to lead 207. But if you then induce spontaneous fission by bombarding it with neutrons, you get these fissile decay products. That's what we've been talking about all day today. That is the material that is being produced in nuclear power stations. Now, the truth of the matter is to get these out of the ground, as the speaker mentioned from New Mexico, it also creates a lot of waste. And obviously, if it's controlled, it's energy, if it's uncontrolled, it's a big bang. Now there's a bit of a spoiler alert because humans didn't invent spontaneous fission. The Earth did a long time ago. And I'm going to talk a little bit about the Oklo natural nuclear reactor in Gabon, because I think it might be informative.

**Dr. James Day:** So what happened at the Oklo nuclear reactor is you had oxidative weathering, early, about 2 billion years ago on the Earth's surface in a supercontinent. And what happened is the uranium is soluble under oxidative conditions and got incorporated into the water. The water hit the water table, it became reduced, and it produced uraninite. In fact, that's how most of the uraninite deposits globally were formed. What happened in this reactor is it was just right to produce a sustained fission reaction in the deposit. Now, this is 1.8 billion years before humans ever showed up. How do we know that? Well, the French were using this for their nuclear power, and they discovered that the uranium 235 in the ore was slightly lower than they would have expected. Very, very slightly, but enough that actually the ore was very difficult to process. Now, those fissile decay products, they're not just radioactive. Some of them are stable. In fact, neodymium is a production of fission reactions and shown over here on the right hand side this is showing you the natural abundance of neodymium isotopes in black and what they found at the Oklo. And if you compare the Oklo ore with uranium 235 fission products from a San Onofre, any nuclear power plant you would care to mention, you can see that they're very similar. So up until this time, we thought that the first sustained nuclear reaction was in the Chicago pile, one 2nd of December, 1942.

**Dr. James Day:** No nature had beaten humans to this feat by 1.8 billion years. It consumed over 6000kg of uranium, produced 15,000MW of power, and that's essentially the same as powering 250 watt light bulbs continuously for that sustained period. Now, here's what I want to tell you about because geology tells us some amazing things. Why was Oklo so unusual? It happened at just the right time in Earth history for this to occur. What I'm showing you here is a plot, and what it shows you is the amount of oxygen in the Earth's atmosphere. Now, for some of you, that may be a surprise. 2.5 billion years ago, there was essentially no oxygen in Earth's atmosphere. For the first 2.5 billion years of Earth history, in essence, there was no oxygen in Earth's atmosphere. The reason that there's oxygen is it was a byproduct of photosynthesizing bacteria and other critters. And it created this thing called the Great Oxygenation Event, or the GOE. That GOE meant that uranium went from being completely insoluble during weathering to becoming soluble. That's what produced many of the uraninite deposits worldwide. And it just so happened that what I'm showing on the other side is the percentage of uranium 235 as a function of total uranium over time. At the very beginning of Earth history, there was weapons grade enriched uranium, if you will, in the Earth. But the decay of uranium 235 has meant that the ratio of uranium 235 to 238 has decreased with time.

**Dr. James Day:** At the time of the Oklo natural nuclear reactor, its percentage was roughly slightly less than a nuclear power plant today. And so it's these just right conditions that produce this incredible event. Now what can we learn from this? Well, we can learn an awful lot about Earth history from this. But we can also learn that life spans of humans are short. Geological time spans are extremely long. The waste must have dissipated in the environment. It must have. I mean, it went somewhere. We don't have such luxuries. So I think the point of my talk is really to emphasize that we need to look more closely at how geological processes through time have dealt, perhaps without thinking, of course, about how to deal with nuclear byproducts. Storage in geologically stable environments seems like a must. I don't think that's unusual to anyone. Concerted international efforts and more geological research are really needed. I would equate this problem to marine natural products. People have used cancer therapy drugs from marine natural products to try and beat cancer. Why are we not looking at geological processes to try and beat this problem? Recycling and reuse. We've talked about this and assessed differ logically defined rules. Everyone's talked about this. Now, for many of you this may come as a surprise, but there are regions of the Earth that are geologically incredibly stable over billions of years. They are called cratons. This is a map of cratons. And what you'll see are well defined cratons in orange.

**Dr. James Day:** You'll notice one sitting in the United States of America. It's called the Wyoming Craton. This craton has been stable for up to 3 billion years. What you'll notice is that Yucca mountain is well

away from that craton. So you've got to also wonder who's making these decisions. Certainly not geologists. But if you were to ask me, where would we look for a solution? I would say in one of these cratonic regions. These are areas where there's low fluid flow, no seismicity, very few volcanics products over the last 3 billion years. And this is where some of our erstwhile Scandinavian partners have been doing some of their nuclear waste repositories. So this is just a very simple explanation to a very complex problem. We can also reuse. In the past, we made mistakes. We have much better chemistry for being able to do automated separation of some of these byproducts. We need to look into this, I believe, and we have much to learn from geology. The current stories of human made nuclear waste is inadequate and does not consider this natural wisdom. That's one thing that's become abundantly clear to me listening to all the speakers today, investment in research and development, combined with the real geological solutions, does offer some optimism. But this is going to require some input and I hope that this gives you some ideas about how we might go about doing that. Thank you very much.

**Dr. Thomas Bass:** Thank you very much for keeping to our time. Time for maybe one question from the audience.

**Audience Question:** Hi. Thank you. I see the image says the first nuclear waste, at Trinity site, but I was wondering if you could talk a little bit about the significance of the uranium that came from Shinkolobwe and how it was so different. Right now they're trying to mine uranium at the Grand Canyon. That's less than 1%. So I don't know if it has anything to do with the natural reactor, but that K 65, if you could explain how do we clean that up or why is it so powerful.

**Dr. James Day:** Thank you for your question. So I don't know the details about some of those sites that you were mentioning, but what I would say is that most natural products will be at about 1.7% of uranium 235.

**Audience Question:** (Clarifies question)

**Dr. James Day:** So 65% uranium is mainly uranium 238 okay. So it's the fraction of uranium 235 to 238 that I'm talking about. Uranium 238 is the stuff they put in Chobham armor in tanks. It's actually radiogenic, but they call it depleted, which blows my mind. But this was actually from the Trinity

detonation. So I did quite a bit of work on trinitite materials. That's why I put it up there. In terms of how we deal with waste globally, it should be about 1.7% uranium 235. You don't see significant enrichments in the Earth. That's what we do. That's what humans do. The Earth doesn't have a very good way of fractionating uranium 235 from uranium 238. So I don't know if that answers your question, but that's the best I can do right now. I'd have to go and look at those specifics.

**Dr. Thomas Bass:** All right. Maybe we'll have time to take questions later if Bart gives us permission. But, Bob Richmond, why don't you stand up and deliver our next remarks.

**Dr. Robert H. Richmond:** Thanks very much. Thank you. And thanks, Bart, for the invitation to come out. Someone asked what Fukushima is. This is Fukushima, over 1000 tanks with 1.3 million tons of radioactively contaminated water from three nuclear reactors that are in total meltdown as a result of very poor planning and execution. I would highly recommend if you just Google was Fukushima preventable? There's an excellent article written by the Carnegie Institute on everything that led to it. I was there last February. As was mentioned, I support the Pacific Island Forum, which are leaders from 18 Pacific nations, Australia and New Zealand, plus 16 that are made up of indigenous peoples to support them in their science. And as the saying goes, no good deed goes unpunished. I was one of the scientists invited to go to Fukushima with the leaders, and what I saw there really scared me. So to put it in context, ocean health and human health are inextricably linked, and especially in the part of the world in which I work. I've worked in the Pacific Islands for the last 45 years, which is interesting because I'm only 39 years old. But as Leona talked about eloquently, the connection between environment and culture is inextricable as well. And this is a matter of cultural identity and practices. When I say individual and community health, it includes not only the physical health. Pacific Islanders have some of the highest rates of non-communicable diseases in the world, cancers among them, but in addition, coronary heart disease and diabetes.

**Dr. Robert H. Richmond:** It's so bad that Palau just had to open a diabetes center and a way of treating people in the islands right now because it's gotten so bad due primarily to changes in diet and activity. And when we look at coastal ecosystems like coral reefs, where I do a lot of my work, it's not only the food they get off the reef, but it's the cultural interactions that occur there. It's where children are socialized. One of the women's groups I work with called the Coral Reef their community psychiatrist. This is where elder women will communicate and mentor younger women, and they deal with all societal problems, everything from drug addiction, alcoholism, family abuse. Without these resources

intact, it's not just about food, but the entire cultural identity and the health of the community, both mentally and physically. It's their economic stability, their ecological integrity, and it's very intergenerational. I love working in the Pacific Islands because whenever I work there with communities and leaders, the first question I'll get is what impact will this decision have on our children and grandchildren and generations to come? When I go to Washington, D.C., two years in the House, four years of executive branch, six years Senate, no one has ever, ever asked me in 30 years of working in Washington on policy, what happens to our future generations. And then finally, the idea of environmental sustainability.

**Dr. Robert H. Richmond:** So I don't have to tell anybody. The present state of our oceans is very bad, and it's only getting worse. This is what I do on a daily basis. And so it's in decline due to a variety of anthropogenic stressors. Climate change certainly is the 800 pound gorilla in the room. Ocean acidification, elevated temperatures and sea level rise are a huge issue for the Pacific Islands, and we're already in our first major wave of environmental refugees from the impacts of climate change. But we also see overexploitation of fisheries resources and a lot of issues with pollution. Everything from plastics to pesticides to heavy metals. Mercury and fish, most people are aware of it. And so the last thing we need is to use the ocean as a continued dumping ground for everything we don't want on land and putting it in the ocean. And it's the cumulative impact. Radionuclides on top of everything else is simply one additional insult that the oceans cannot handle with these fragile ecosystems. Regarding radioactivity in the environment and especially in the ocean, it has effects on human health. This is truly a transboundary and transgenerational issue, meaning that the water released in Japan is not staying in Japan, it's moving its way across. And in the year 2011, when Fukushima disaster occurred, tuna caught off of San Diego off of Scripps were found with cesium 137 that could be traced back to Fukushima. It's making an occurrence.

**Dr. Robert H. Richmond:** It's making it in fish. It was at very low levels. But remember, this discharge is supposed to go on for at least 30 years. Our expert panel did the calculations. We think it's going to be more like 40. And so when you have tuna that can live to be 22 years old, you can just do the math and figure out this is not a good idea. We don't know the impacts of climate change on the chemistry of what it will do to the radionuclides, and this is an important black box that we need to figure out. And then, as I mentioned, ecological, cultural and economics, there are better options that exist. One of our calculations we did on the panel was putting the water into concrete to be used on site. During my visit to Fukushima, the biggest issue was they were told to build a seawall, to expect a 15 meter tsunami, and they decided not to do so. They were even told by the International Atomic Energy Agency four years in

advance, the response we got from the people at the Tokyo Electric Power Company, they didn't want to scare the people of Fukushima by building such a high wall that it would make them worry that a wave that big could come. How's that for nice intelligence? So we looked at different options, and those do exist.

**Dr. Robert H. Richmond:** Me as a marine biologist, the biological concerns that I deal with on a regular basis is that dilution is a chemical process. Bioaccumulation is a biological process. And for all the physicists that are saying, "you calculate the volume of the ocean and you calculate the concentration of radionuclides, no problem." As soon as the radionuclides enter the water. Big problem uptake, trophic transfer and bioaccumulation and biomagnification. And these are the things that we've studied. This truly is a time bomb, meaning that what's being released today is not going to show up for a while, but when it does show up, there's no way of getting the genie back in the bottle. When they get into fish, when they're found, there's no way of getting them out again. And people talk about, well, it's low level beta emitters, not like gamma rays. Well, actually low level beta emitters like tritium and the other 62 radionuclides that are in this mixture, low level beta emitters have what's called a higher RBE. Relative biological effectiveness because they get embedded into tissue, unlike gamma rays, which are like kind of a through and through shot if you want to use that analogy. These get embedded and they continue to release ionizing radiation over time. And a couple of them in particular, there's been a lot of focus on tritium because it cannot be removed by the advanced liquid processing system and carbon 14. Tritium has a half life of 12.3 years. Carbon 14 5730 years. So you can see this is not minor, but tritium can be taken up and is called organically bound tritium.

**Dr. Robert H. Richmond:** Strontium 90. The nickname is the bone seeker because it replaces calcium. It gets in the bones and the bone marrow is where your blood cells are constantly turning over. The last thing you want are low level beta emitters getting stuck into the bone and emitting ionizing radiation to your blood cells are constantly turning over. When we take a look at organically bound tritium, there is a pretty good literature and it's getting better all the time that it not only gets into sediment, it gets into fish, but it can actually be trophically transferred. There's an inescapable form and an inescapable form. So it's not just hydrogen. It's hydrogen that gets bound to tissues, gets bound into lipid and gets transferred up and can be accumulated with a biological half life of over 500 days in the liver of a fish. And then finally, these plumes of radionuclides are modeled in one case of being able to sit over the Pacific in about 7 to 12 years over the major fishing grounds. Bart, I did put the slide in. I'll show it in a minute.

**Dr. Robert H. Richmond:** So here's just kind of a quick view. Here's a cartoon of a tritium atom. Here's a carbon 14 atom. Neither tritium nor carbon 14 can be removed by the ALP system. There are also very dodgy data that we've seen for many of the other ones, like strontium 90, cobalt 60, ruthenium 106. Those are the ones that actually worry me even more. But as we look at what happens, these can get into the phytoplankton. Hydrogen and carbon are quickly taken up by phytoplankton that go to zooplankton or into the sediment. We have sediment feeders, we have things in the water column, and all of these are the ways of getting it into people and has been said before, there's a big difference between an external exposure to a radionuclide and a beta emitter versus an internal one. Once its internal game changer. Your skin and clothing will stop beta emitters. There is no protection against beta emitters once they're taken internally through inhalation or ingestion. And there's two types of DNA in animal cells: nuclear DNA and mitochondrial DNA. Nuclear DNA has a little bit of a membrane around it, and nuclear DNA has a little bit better repair mechanisms. Mitochondrial DNA has no protection whatsoever. This is your energy system, your immune system signaling proteins. And these are the kinds of damages that during when we reviewed their radiological environmental impact assessment, I asked him, where are the molecular tests? Where are all the ways of looking at sublethal DNA damage? One of the phrases in our laboratory, we do a lot of Ecotoxicology is "death is a rather crude estimator of stress." We don't do that in human health, and we don't do that in environmental health. If you're dead, it's too late to intervene.

**Dr. Robert H. Richmond:** So we have a variety of things we do. We have a suite of tests that we can do for oxidative damage, comet assay, DNA, epi sites that can tell us. When I asked the genius scientist at Tepco, where are these things in a radiological impact assessment? Well, we didn't want to do those. So these are the things that are very, very concerning. This is the modeling from some Chinese researchers of day 120 from the plume release 1200 2400 and 3600 days, meaning three years, six years and 12 years of where they model the plumes to go doing two different models. This is right in the middle of the major tuna fishery zones that we expect. So I'll finish up by saying that the policy has not kept up with science by any stretch of the imagination. We know far better. And the IAEA, I hold them responsible because they're not stepping up and doing what they should. And the issues for thought I'll end with is monitoring doesn't protect you from damage. It tells you when you're screwed. If you smoke three packs of cigarettes a day and say, "hey, no problem, I'll get a chest x-ray every year." When the lesion shows up, you say, "all right, I'm done smoking. I'm good." No you're not. And this is the biggest fear that I have on the biology. Thanks very much. Thank you.

**Dr. Thomas Bass:** Professor Richmond, thank you very much. That was great. Time for one question. And then we move right along here. We have a question from one of our experts, Paul Gunter.

**Paul Gunter:** So thank you very much for that. The question is, so tritium displaces stable hydrogen. Correct?

**Dr. Robert H. Richmond:** Not necessarily, but it can be taken up.

**Paul Gunter:** So I guess the question is can tritium move upstream if when it's released?

**Dr. Robert H. Richmond:** So the question was can tritium move up? Yes, absolutely. And that's what organically bound tritium is. What happens is it gets bound into organisms and tissue. And then it can be passed up through trophic transfer. So from phytoplankton to zooplankton. And that's one of the issues we brought up with Tepco and the Japanese. It was interesting. We weren't meeting with their Environmental Protection Agency, their marine resource agency, or their science agency. It was the Ministry of Foreign Affairs, the Ministry of Economy, Trade and Industry and Tepco. And I asked them, where are your scientists? They weren't. And so these kinds of issues we brought up to them. One of the experiments they set up for their monitoring program was to put a bunch of bottom fish in a fiberglass tank and feed them aquaculture pellets, and then they had a video camera and said, see, they're not dead. And that's where we said, okay. Death is a rather crude estimator, the tritium, this is what they were using for their tritium experiment. I said, okay, so what do these eat? Do they eat aquaculture pellets in the environment? Well they say well no. Well if you wanted to do it, put sediment in the bottom of the tank, put the bottom fish in the tank, put crabs and worms and snails in the tank as they eat the tritium that gets into the bacteria. Then it will work its way up. They said, no, that's too complicated. Their response was they got the director general of the International Atomic Energy Agency, Rafael Grossi, to pose with a bottle of aquaculture pellets above this fiberglass tank and say the science is impeccable. That's their response to tritium uptake.

**Audience Question:** (Audience Question)

**Dr. Thomas Bass:** Ah yes. The question is apparently the batch releases from San Onofre. But of course that's a different kind of water than water from reactors that have melted down.

**Dr. Robert H. Richmond:** There's a big difference between water that is in a heat exchange system versus water that's in direct contact with three chords that are in meltdown.

**Dr. Thomas Bass:** Exactly. So thank you very much. Stick around afterward for the serious questions. Thank you. Thank you very much, Bob. That was terrific. Now we have Kim McCoy, our expert in sensors and keeping track of what's actually happening on the beach with the waves and water. So I turn this over to you, Kim McCoy.

**Kim McCoy:** Alrighty. Well, there is (referencing slides), what we're going to talk about what happens to a hard body when it meets the surf. And that's not my hard body there. That's Kelly Slater at Trestles, which is not too far from San Onofre. And I think we have the acting mayor of San Clemente here. Stand up there. Right. Have you? And he surfed at trestles pretty much your whole life, right? We're not so far. It's not over yet. All right, so here's some other vulnerable hard bodies in the surf. So right here we have a coast that comes in. So I'm an oceanographer. I've spent 40 years going around the world. I've spent about five years of my life at sea. I designed and built oceanographic instruments that have taken millions and millions of data points at sea. And, I'm still doing that. Anyway, so here's a hard body, right? A couple of them here. This is before they put in the storage facility there. That's reactor one that's now gone. As we've seen before, some of the rebar is already exposed in that area. So what happens when these things get exposed to the forces of the ocean? So here we have this seawall. You've seen that in other presentations. So this is what I'm going to talk about mainly is the last 10 to 15 years of studies that have been done using sub bottom profilers and side scan sonar.

**Kim McCoy:** So this is a beautiful image. I'll show you a bigger one later. And here's San Onofre in this red circle. And it doesn't take a rocket scientist to recognize that this doesn't look very stable. And slides on land, landslides on land, they need about 15 degrees of slope. Underwater you need only about two degrees of slope. So don't think that just because that's not falling, this isn't falling. You can see it has fallen quite a bit. So there's Oceanside Canyon, here's Newport Canyon. Here's a bigger picture. So San Onofre is right in here. And this is a beautiful image. So this is from peer reviewed publications 3D seismic imaging homes. Driscoll. Driscoll, as you see at UCSD, is professor there. And then this is a

European publication. So this is distribution for large, larger than 100m by 100m by 100m, which is submarine landslides, which is way, way larger than all of SONGS. So these images, this is Catalina Island here, right here's San Pedro. And so we've got the largest container harbor on the West Coast, I think is LA in the LA basin, together with Oakland up north. All this would be compromised if you had a little event down here. And as we already know, in the deep ocean here, this is about 3000ft deep. So about 1000m deep. They've already disposed of DDT and they found radionuclides down there too. So this is an image this is actually from the Mediterranean. I believe this is a European publication.

**Kim McCoy:** And this gives you an idea. This is the edge of the continental shelf and it's collapsed. And look at all this debris down here. So it's not as if these things are just occasionally occurring. Over the last 15 years, they've realized that these things are two orders of magnitude more frequently occurring. That means over 100 times more submarine subsidences, submarine landslides, slumping than previously known. And it's right here in our backyard, See those red squiggly lines? Each one of those is a fault. And here we have the Newport-inglewood fault zone. We're right here, right on the right on shore from the Rose Canyon fault. And in the last 15 years, they've determined that this is a contiguous fault line. And that fault, the Newport-inglewood fault combined with the Rose Canyon, now one contiguous, is capable of about a 7.5 magnitude earthquake. Likewise, offshore in the San Diego Trough Fault, it can also generate about a 7.5 magnitude fault. Now, I'm not talking about the tsunamis and all that that we already know occur. I'm talking about just the shaking. And when it shakes, it can collapse. So what we have here is in 1933, there was a 6.3 magnitude earthquake, and people died in 1933. And that's just north of where San Onofre is right there. And in 1996, at Echo Arch, which is in the state park just south of San Onofre, just about a mile south they started having slumps, landslides, and it continues to this day. So, Adam Young, who's a researcher at Scripps Institution of Oceanography, has written extensively on that. And so we're not thinking about, when it could happen. It's actually happening now.

**Kim McCoy:** So this is to explain the difference between a landslide and a slump. So when you have heavy rains up here inland, so up here when it rains, what happens is it comes down in, it gets into a fault, into a crack. We've all walked along a street and see a little crack in it. You go, water goes down there. Well that happens all over in nature. And if you have large faults like you have along the coast where San Onofre is, that's happening too. So this is from Adam Young, 2015. So less than ten years ago. This whole thing can slump down. So see this? Imagine how you slump down in your chair. That's what happens. This whole thing rotates along the slip surface. And now imagine San Onofre with its seawall right here. Right. What happens to that? Well, it goes down now. How well is that seawall going to survive when it's maybe three feet lower now? In 1964, when they had a very large over nine magnitude

earthquake. Square miles of the earth subsided. 30ft. That's ten meters. Can you imagine that? "Now we've only got 7.5 potential", they say, but it only needs to slump a couple of feet a meter, and it's really completely toast. You saw the pictures of the seawall earlier?

**Kim McCoy:** So one thing I want to point out again is see how this comes in here and right here. Someone else pointed out this indentation. Now, if you just draw a line along here, what's wrong with all that whole storage facility? It doesn't look like it's the rest of the coastline. It shouldn't be there. They excavated a whole bunch of the topsoil this stuff up here when they built the thing in the 60s, but nevertheless, underneath it can still slump. And I'm going to show you something now. This is Black Speech in January of 2023. Watch this face right here. Okay. So watch the one face up here.

**Kim McCoy:** (Plays video of Blacks Beach collapse) See that distance increasing? This thing is slumping down. And this is rising up. This is about 15ft high. So about five meters. Likewise this has got about five meters slumping down. Now imagine that at San Onofre it would be catastrophic. That's about the height of the seawall. And that's just 2023 at Black's Beach. And these are happening all along the coast. We have a rising sea level and it's just mainly sedimentary rock. So it's not really something that you want to have happen in your backyard.

**Kim McCoy:** So what's the infrastructure look like there? Here we have, wow, that's a great state of the art. That's San Onofre. This is a north side of San Onofre. And so you can see even at these high tides, you get erosion. You see all sorts of stuff coming up from the sea. This doesn't really look anything in comparison to these large blocks of cement which used to be over here. Now, see the height of a human there. You tell me whether or not this infrastructure is anywhere as robust as what we see on the left. So we also have increasing high tide flooding because of sea level rise. That's happening all over.

**Kim McCoy:** And just I'm not a nuclear kind of dude, but, Holtec is non-ASME, that's American Society of Mechanical Engineers, it's not certified by them. They self certify their 316 L stainless steel hot canisters. And there are some self certifications, I heard some of you read a little bit in advance there. Of course Holtec does it. They have admitted many violations. They've been fined as other speakers spoke. And they certify their canisters on land. And of course, Boeing certified their 737 Max. How'd that work out? And some of you might remember Oceangate that Titanic submarine. They were also self certified, right? Isn't that good?

**Kim McCoy:** So inside of these canisters, this is actually a Swiss version, how they do it properly. And it's modeled the temperature inside 300 C. That's about as high as your oven goes at home. And you know this is boiling water temperature. So you can see it gets pretty hot in there. And the canisters at San Onofre, they need that heat flux, that air flux to keep them cool. And each one of those canisters at San Onofre, the 73 vertical ones manufactured by Holtec, radiates about 1.5kW. What's that mean? Well, if you've ever done a potato in your microwave, your 1.5kW oven can cook your potato in three minutes, so you've got a whole bunch of microwaves there going. And that's a low number. I think the canisters are certified for about 30kW.

**Kim McCoy:** So think about the infrastructure I just showed you. And now think about the wave forces, the wave forces that are constantly at work in the ocean. Raise your hand if you've ever been to sea. Oh that's amazing. Probably at least half the room. And tell me if you've been in this. (Plays video of ship at sea during storm) Those are the waves created by the wind, which are created by solar radiation that creates a temperature difference and create the wind. Those. Those containers will not withstand the sea. There are scores of ships that are lost every year, about 200 per year. And there are about, it varies between year and year, but roughly between 1 and 2000, containers are lost overboard every year. And if you think that San Onofre is going to withstand a big storm, something like we had in '82, '83, in El Nino years, there's more wind, more intense winds that are coming along, creating bigger waves and San Onofre hasn't changed since they built it in the 60s. So things are really changing.

**Kim McCoy:** What happens when it gets into the surf zone? So this is a beach in Greece. And watch what goes on below. (Plays video of waves below the surface) So these are little waves. Watch the sand get resuspended. Pretend that's a canister right there. So whoop! And now watch the biology. See the fish? They come by and they suck up all those radioactive pellets that have been turned into soup, right? Splashing around in all the aerosols go into the atmosphere. And what happens? Those aerosols don't just stop. Diffuse. Those aerosols keep going. The evacuation zone, if it gets into the surf, will be way, way more than 50 miles. Way more than way, as you can see. Biology is intimately connected with the waves, and whatever gets into the surf zone is toast, right? So in conclusion, what you got to ask your family is do you feel lucky? And then after you ask them, go to a realtor and say "where would real estate prices bottom out if something like that happened?" And I think it's pretty much zero because you probably wouldn't be able to sell it. So there I am. Thank you very much.

**Dr. Thomas Bass:** Perhaps time for one more question. And then, we move on to our next panel.

**Audience Question:** I just wanted to actually continue what I started to say before because for the funding, I mean, you're just this last point is how cost effective it would be to address this before we get to a point of disaster. And meanwhile, there is money that the DOE has been spending for consent based siting. And I just wanted to make this point because consent based siting is trying to come up with sort of use this like logic of inclusion, but to basically justify where to site the nuclear waste. So there's more than $20 million that was used for this. So the consent based siting essentially for future generations cannot give their consent. So this is money that should be used toward addressing solutions. And so I wonder if you could just address in terms of this argumentation. Who should we be directing this toward? Thank you.

**Kim McCoy:** Funding. You know, money is the axle axles grease the grease on the axle. I believe if someone can figure out how to value the future value of nuclear waste or the future loss that a corporation will have if they keep creating nuclear waste. Perhaps the money process will answer that question automatically, and funding will be made available, or companies will go bankrupt, and then insurance companies will change and the dynamic will change. But as it is right now, it ain't going to change.

**Dr. Thomas Bass:** Well, thank you very much to that panel. Another fascinating series of presentations.

## Panel Five: Ensuring Effective Monitoring and Policy: What Can Be Done?

**Rita Macdonald:** In our next panel we have Stephanie Cook, Roger Johnson and Professor John Orcutt. I think we have an amazing panel to talk about ensuring safe storage and effective monitoring.

**Dr. John Orcutt:** All right. I think we can get started here. I came to Scripps in UCSD in 1973 after serving as an officer on nuclear submarines. I'm a Naval Academy graduate and did my PhD here. This picture

that I have here is a part of my training in the Navy. It's in Idaho, of all places. But there are several reactor plants out there that the Navy has built mock ups so that people could actually experiment with these things, learn how to actually operate a nuclear plant. And this is a picture of the submarine that I got. It's a cylinder. But it's a free circulation system. It doesn't have pumps to actually pump the water from the reactor to the heat exchanger, which creates steam, which makes the ship move forward. So it's rather unique, but it was quite an interesting undertaking. One of the things I did at the end of the time in the Navy, under DOE's office of Nuclear Submarines, was qualified to refuel a plant. And this I refueled the Kamehameha. I was in charge of that. Hyman Rickover was still working and talked with him almost every day. He paid a lot of attention to this, but this is where it went in Washington.

**Dr. John Orcutt:** These are the casks, one of these. And then I have no idea which is my reactor. And that's an example of storage of these casks after they have been used. And you can see there they eventually will cover these with soil. So this is a national program. Ut works at this point, but we don't really have a good way, apparently, of dealing with commercial plants.

**Dr. John Orcutt:** This is the Yucca mountain facility that was built just a few years ago for storing things like the spent fuel, at San Onofre. It was to be a national system. It's near the nuclear test site where lots of bombs were tested over time. It's a very contaminated sort of place. It's not a really comfortable place to go to and walk around, but it is possible. And this shows one of the shafts in that facility. There was strong opposition from the people in Nevada to have this site. Millions and tens of hundreds of millions of dollars were spent on this what could be a national facility. But it is unused and probably never will be used. One of the biggest problems and it's been emphasized all day here today is there's no real national program for taking care of commercial waste, and you're winding up with trying to deal with facilitating this long term storage at San Onofre, which is not the ideal place to be doing that kind of thing. But there are places on the planet or in, in the US itself, including Alaska and other places that we should pay attention to. It is something that we need to pursue with much more vigor.

**Dr. John Orcutt:** One of the things that I think about a lot is the CO2 in the atmosphere. This continues to build up over time. When I first came to Scripps, Dave Keeling had just started. He had about three years of data. I think you're all familiar with that, that plot. But it shows the increasing amount of CO2 in the atmosphere with time, and it is increasing year by year, exponentially. It's a concave upward change. It's not just a linear change from year to year, but it's getting more and more worse all the time. And so we think we're making some contributions now with government programs to reduce CO2. So far they have

had absolutely zero effect and the same kinds of things attend the treatment of this waste. We were not making a lot of progress. We need to move forward. And this is an opportunity to think about this and get rid of this CO2 problem, as well as how do we deal with energy. We can't continue to use these various systems for material in the atmosphere and in the Earth.

**Dr. John Orcutt:** We can handle things like this. In the past, when I was younger we did a lot of nuclear testing in the atmosphere. We tested nuclear systems and so on, but we actually and Scripps had a great deal to do with this in the end. There is no longer any testing of nuclear warheads and so on Earth. There is the president or the potential president proposed this just a few days ago that we should start testing nuclear warheads again, which is the most incredible idea that I've heard from the candidates for president. So these are all tied up with it just seems to be the same problem going around and around. We did happily for many years, and hopefully it will go into the future. Stop testing nuclear plants. So that's just the issues that I wanted to bring up.

**Dr. Roger Johnson:** Thank you. And thanks to the Samuel Lawrence Foundation and to Rita and Taylor and others who have put this all together. And we've learned so much today. I guess we're behind schedule, right? Yeah. So I'm going to try to rush and skip some things. One thing we learned from Gordon Edwards earlier you mentioned a lot of historical things that were really quite relevant and quite scary too, we have to learn from history. History repeats itself. I'm going to try to wander through history a little bit, and it's kind of scary because the nuclear age has changed civilization. And there are some scholars out there who say the human race has about 100 years to live. We'll extinguish ourselves. Biological tissue doesn't survive ionizing radiation. We have two wars going on right now. Either one could result in nuclear conflict. So we have to learn from history, and we have to stop repeating it. Right here 20 miles away we have 1773 tons of nuclear waste sitting on a beach. And that's pretty scary. Some of this waste will decay rapidly. Some of it will decay in a hundred million years. So we have no plans on what to do with it. That's pretty alarming. So there's two issues here: what might happen in the future with this nuclear waste, and the other thing is to take a look at what's happened in the past and how it's affecting us.

**Dr. Roger Johnson:** So, I'd like to look at that a little bit, because for the last 67 years, San Onofre has been depositing, releases into the ocean and atmosphere. Every nuclear power plant discharges into the atmosphere and into the waterways. There was one last week, 118,000 gallons. They have 18 pipes 18ft in diameter, and there are 65 portals five feet in diameter. The plant has been closed for ten years and

they're still doing it. They do it about twice a week. So some have calculated that there have been almost 10,000 releases of low level radiation into the atmosphere, into the ocean. And so we need to know about these health effects. These releases are called low level radiation. But one of the important things to remember is that it's cumulative in its effect on biological tissue. So when you go to the dentist, the dentist says, "oh, it's nothing", but maybe you've had 100 dental X-rays. You know, it all adds up. So we need to know more about this. So there's a long history to this, and some of it is scary. The government has been involved in lies and deception about radiation and cancer. And there's a current president who partly got elected because he said he was going to conduct a moonshot on cancer, and guess what? His agencies are blocking cancer research.

**Dr. Roger Johnson:** So that's where I'm going to end up today talking about the studies of the National Academy of Sciences, which wants to study cancer around nuclear power plants. But so far it's been blocked. If we go back to 1895, Wilhelm Röntgen discovered mysterious light could penetrate the human body. You call it x rays, X for the unknown. And then a year later, Becquerel studied uranium, a mysterious element he didn't understand. And he combined with Marie Curie. They both got Nobel prizes. And guess what? Marie Curie died an early death from cancer. Somebody mentioned it early today the Radium Girls that were paid to paint radium on watches, watch faces so they would glow in the dark. And guess what? They all died. horrible deaths. The owners of the plant that hired them said that they died not from radiation, which is harmless, but they died because they got syphilis.

**Dr. Roger Johnson:** Now jump ahead. Albert Einstein met with President Roosevelt in 1939 and said a chain reaction from nuclear, from uranium could be harnessed into gigantic bombs. So that the Manhattan Project was started under General Groves. A significant amount of resources for World War Two were diverted into the very expensive Manhattan Project. Skip to 1944. General Groves tried to enlist Nobel Peace physicist Joseph Rotblat. Groves said to him that the purpose of the A-bombs was not the end of the war. The purpose was to scare the Russians, to threaten Stalin. That's the same thing they did when they bombed Dresden. You know, Dresden was saved up for morale in World War Two. They didn't bomb at all. They saved it up so they could totally destroy it. And the purpose was to scare Stalin. So Groves said that that was the purpose of the atomic bombs. But in fact, in July of 1945, there were secret negotiations going on, and Japan had already agreed to surrender. But what held it up was the emperor. Emperor Hirohito, they wanted executed him as a war criminal. The Japanese refused to agree to that. And so, the war was about to be over, and the people with the atom bomb were terrified that a war was going to end before they could drop the atom bombs. By the way, I lived in Japan in 1948 to 1950 as a kid, and I rode Emperor Hirohito's White Stallion. They took the stallion away from the

Emperor. They put him in a camp drake, the first Cavalry Division outside of Tokyo. And that's what I did. I stole a license plate cover off of general MacArthur's limo one time. I played, I played. Anyhow, I can't talk about that. Okay, let's let's get away from humor. This is not funny.

**Dr. Roger Johnson:** The two atom bombs they developed, there were a lot of internal debates. Why not blow off the top of Mount Fuji? Why not create a tidal wave in Tokyo Bay? And they said, "we want to test it on a populated city." So that was the same strategy against Dresden. There were two, two bombs. As you all know, the first one was the uranium bomb. A gun type bomb. You slam one one hunk of uranium against the other. And the second type was a plutonium bomb with an implosion device that was Nagasaki. And you know about the Nagasaki raid was almost, well it wasn't a failure, but they rushed it because they're afraid the war would end. And so the cloud cover was over Japan, and they sent off the plane anyhow. And it kept going from target to target. Couldn't find any, any clear city. That's how it ended up in Nagasaki. And then they finally had to almost ditch the bomb or else drop it. So they dropped that. They missed the target by four miles. And then the plane went back and ran out of fuel and almost crashed, landed. And the cruiser Indianapolis delivered the A-bomb for the Nagasaki raid, and it was sunk right after it delivered the bomb.

**Dr. Roger Johnson:** After the war studied the Japanese who didn't die from Hiroshima and Nagasaki. So that study they never helped anyone, but they studied them. And that led to the human radiation experiments which started after the war. And, you could buy a copy of this from the US Government Printing Office. It's about the size of a Manhattan telephone directory. And there's 4000 experiments were controlled where they injected radiation into pregnant women to see if it would go to the fetus. They irradiated the testicles of prisoners and so on. Then they set up the RECA act, the Radiation Exposure Compensation Act. They spent $2.5 billion on this so far for the downwinders, for the people that were exposed to radiation. It's controversial now because it expired in June, and now the Republicans are trying to hold it up. The National Cancer Institute in 1991, decided they wanted to study cancer around nuclear power plants, but it was a terrible study and they found nothing. And since then there haven't been any studies. But concerned scientists in Europe Doctor Ian Farley mentioned in his writing that there have been over 60 scientific studies done about radiation around nuclear power plants in Europe, and they have reported cancer effects in children in particular.

**Dr. Roger Johnson:** We know that women are much more sensitive because of reproductive tissue. They didn't study women. Children are also and the human fetus is about 50 times more vulnerable to ionizing

radiation. So the NRC finally, in 2010, asked the National Academy of Sciences to review literature. They didn't want them to do research, review the literature on cancer near nuclear power plants. And so the National Academy came out with a report in 2012, 500 pages long, and it ended up concluding, we need to do research. So the NRC went back and said, "well, we don't want any research, but can you write another report telling if research should be done how would we do the research but don't do the research." So they did another study. This was published in 2014, and they recommended a pilot study. Pilot study included six nuclear power plants, one of which, the only one west of the Mississippi River is San Onofre. And so they were going to study the 50 mile radius, 50 kilometer radius around San Onofre. That's Huntington Beach. There's Solana Beach. So we would have been part of that project. And so they went back to the NRC. The NRC said "no, we rejected that. We can't afford it. We have a $1 billion budget and we can't afford $7 million. And besides, we already know you won't find anything." So that died until our congressman, Mike Levin, who can speak here shortly. Mike, if you're listening, I hope you comment on this. You work with colleagues and got it funded through Congress to a different agency. This time, the HHS. The HHS sat on it, and then they convened a secret committee, which included representatives from the nuclear industry. They excluded the scientists who are doing the study. And guess what? They rejected the research. They thought it was premature. That's what they said. It was premature. And that's where it stands now. With the studies, the government, two agencies have rejected the research on cancer in their nuclear power plants. Cancer is the number one killer in California. It's the number one killer for most of the nation. No one seems to know where this or this is headed. And I've talked to my colleagues at the National Academy last week. And they don't seem to know either. But this is where we stand. We're not going anywhere. History is terrible. And let's not repeat history. We have to get serious about this.

**Rita Macdonald:** Thank you.

**Stephanie Cook:** Hi. I'll try to make my speech short. I think what I'd like to do is go back to the beginning of our amazing day and talk about this idea of a plan for San Onofre to begin with, which would be to get those canisters replaced with decent casks and removed to safer ground somehow, somewhere. I can't say where or how you get there. The wider picture, which we've been given many, many facets, fascinating facets today is that there is not an easy solution. I don't know if there is a solution per se to waste. I have been hearing about consent based siting and permanent repositories since I started reporting on this industry back in 1980, and nothing has happened to indicate that any of this is going to transpire any time soon. So I would say that we need to have a reality check about waste and say, pretty much like no one wants a waste repository in their state or in their town. Number one. So then you go

back to the question of why is there so much hype about nuclear energy? I've been asking myself this question well for many years. The latest incarnation of this hype seems to have started after Fukushima when GNEP failed, GNEP being the hype program that Bush started that resulted in two reactors at Vogtle in Georgia, and there were something like what 30 applications or something like this that all folded because they just weren't they weren't going to happen. Then Fukushima happened. And guess what? You couldn't build a large reactor after that. It was just untenable.

**Stephanie Cook:** So then the DOE, in all its wisdom and a lot of sort of amazingly progressive groups who were concerned about climate change, latched on to the idea of small modular reactors and advanced reactors, most of which had been thought of and designed years and years ago. It's like DOE just pulled it out of its little treasure chest. So you have to keep going back to the question why? You've heard pretty much irrefutable evidence that nuclear energy is not economic. It leads to all these problems of waste. No one talks about waste when they talk about tripling nuclear energy. They don't talk about it. But just getting back to this hype. The only answer I can come up with is that the answer that Moniz, the former energy secretary under Obama, provided in a 2017 report when he said we need a civil nuclear sector to support our military nuclear program. Now, many people in the military, if you talk to them on the side, say we don't need the civilian nuclear program, but they're worried they won't have the brain power, they won't have the research funding. And they've always had a kind of symbiotic, maybe like unhealthy codependency since the beginning of the nuclear age, since atoms for peace. So you kind of have to go back to that and remember that that exists also.

**Stephanie Cook:** And then you get to the question of, well, will we just constantly be repeating this cycle of hype and spending like we've in this country, we've spent probably 50 billion since the year 2000 hyping nuclear energy, and we have three gigawatts to show for it, which is the finished watts of our reactor and the two Vogtle reactors. You have to go back to that, and you have to ask very hard questions. Are we going to keep wasting money on nuclear energy because we have to support the bomb program? And if that's the case, what are we going to do about the bomb? I'm not going to go into the bombs, because that's a whole other subject, and it's a very difficult one. But those are the kind of questions that are on my mind. And I'm sorry I can't be more positive, but I think we really need to stare it in the face and say, I think what Greg was advocating earlier about privatizing is a good idea, because when companies can no longer have handouts, like Amory said, it's their new business model farming subsidies. That's their new business. He's absolutely right. We have to stop giving them money, tell them to survive on their own, or just get out of the business if they don't like it. If they can't find a place to put

the waste, too bad if you don't want to take the risk and you can't find insurance, well, find something else so you know you have to do it like that. So I will stop there because I might go on forever.

**Dr. Roger Johnson:** You mentioned Ernest Moniz, Secretary of Energy, which is a big champion of everything nuclear. So he well, he went on the Bill Maher show a couple of years ago promoting nuclear energy. It's clean and green. The whole Department of Energy is clean and green. They want to spend more. Moniz went back to MIT. MIT gets about $200 million a year from nuclear support. Guess why they're interested. Of course it's it's. The academics are doing it, too, and they want to support it. All things nuclear. They make a lot of money off of it.

**Stephanie Cook:** I would say that also, Congress needs to wake up. Everyone needs to wake up the progressives who think this is a solution to climate change need to wake up. Ask them where they want to put the waste. People want to say, “oh God, I've heard enough about that.” You know, there's no conversation about waste. This is the first serious conversation I've heard about waste in years. So thank you for having it. Yeah.

**Rita Macdonald:** I'd like to ask the audience if they have any questions.

**Audience Question:** You mentioned the Keeling Curve, and that it indicates that the amount of oxygen in the atmosphere is declining each year. But what about the Ralph Keeling curve? Keeling's son is doing a similar study and showing that the amount of carbon dioxide, percentage wise, is increasing in the atmosphere every year, and we don't hear about that. Mike. I have huge questions. How much does the increased carbon dioxide in the atmosphere that's shown by the Ralph Keeling curve, affect human development? And if we have a lot of carbon dioxide in the atmosphere, are our babies developing normally? And is their mental acuity going to be the same, or is it going to go down and okay. I'm from Illinois and we are fighting carbon dioxide accumulation and piping and storage under Illinois.

**Dr. John Orcutt:** Yeah, it's increasing the level of CO2 in the atmosphere exponentially. As every year goes and it's really poisoning the atmosphere, it needs to be reversed. And one of the ways to do it is not to fire more coal and natural gas and fuel and gasoline. We have to stop using that material. We have to use a different way of providing energy. One way, one solution and it needs to be looked at very carefully

is the nuclear power approach. Wyoming some of you may know is building a new nuclear power plant there through Terrapower which is funded partly by Bill Gates. This will be the first realization of this. And the governor, a Republican, actually, is looking forward to increasing the amount of energy he ships to California, where we don't have any power. So, you know, this is a very, very, very difficult discussion because we can't continue burning fossil fuels. It's got to stop. There has to be a solution. Solar helps, but it's not the long term solution. It's growing very quickly. And we're making much more use of it in the last 2 or 3 years. And that's a partial solution. But we have to think much more broadly about the energy thing, and how can we have this kind of energy in quantity that can support a growing, rapidly growing global population. There's nothing simple.

**Stephanie Cook:** Just real quickly, I just wanted to point out that among the monies that have been spent on experimental advanced reactors and small modular reactors, the first two lead small modular reactor projects that the DOE funded both collapsed, the last one being Nuscale. The next one up, we'll see this is the advanced reactor program is exactly what you're referring to. But that is actually just breeder technology that Jimmy Carter and Ford said no to back in the 70s. It's expensive. It's complicated. It's, you know, sodium cooled. I don't see why we're trying to reinvent a wheel that never worked in the first place. I just wanted to say that. Thank you very much.

**Rita Macdonald:** Thank you very much. Okay, one more question, please. In the back.

**Audience Question:** Regarding pushing nuclear power into the private sector, do you see a possibility of a risk of it backfiring by increasing the number of irresponsible players in the market, as we've seen in other industries like genetic engineering.

**Stephanie Cook:** If the private sector is responsible for liability and they're responsible for finding waste, I just don't think there would be much interest. Every single reactor project right now, whether it's in the United States or somewhere else, I'm not aware of any that are totally self funded. They all have their hands out and they're taking government money. And it's keeping a few people employed and scientists happy because they get to experiment. But it's not really producing any energy. It's not taking any carbon out of the air. So as for doing it in the private sector, it's just asking the industry to behave like every other industry does and see what happens. I don't think it would go very far.

**Kim McCoy:** Thank you. A quick comment. This is about nuclear waste. Currently, we don't have any solution to what to do with the waste. I'll make an analogy. You've got a dog. Your dog poops somewhere. You don't know what to do with the poop. You put it somewhere. Where is the rationale that you need more dogs before you figure out what to do with the poop?