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March 3rd, 2023 - Jacobson

Bart Ziegler PhD, President, SLF (00:00:00):

Hi, I'm Bart Ziegler, the president of the Sam Lawrence Foundation. And good each of you made time in your day to attend this especially remarkable webinar. We're honored to have with us, Stanford University, professor of Civil, and Environmental Engineering, Mark Z. Jacobson, to discuss his recently published book. And we are very fortunate to have Ken Cook, president and co-founder of the Environmental Working Group, who's an advocate for public health and environmental protection. Let me just make a quick shout out to the partners, which include, Beyond Nuclear, N E I S, N I R S, California Climate Voters, Mothers for Peace, Nuclear Consulting Group, Environmental Working Group, and Sierra Club of California. Without collaboration and partnership, we will not do justice to the planet. I'll hand it over to you. Ken Cook. Thank you very much.

Ken Cook, President & Co-Founder, EWG (00:00:59):

Thank you very much. I'm thrilled to be here. If you're a fan of Mark Jacobson, just line up right behind me in an orderly fashion. My job here is to introduce Mark a little bit and his book, which I enormously recommend to all of you, and then to moderate the chat. So the ‘rules of the road’ are: if you have a question, please type it into the chat.

(00:01:49):

The book is called *No Miracles Needed: How Today's Technology Can Save Our Climate and Our Clean Air*.

(00:02:44):

Today's technology, super, super important. First of all, I think it's the best sort of narrative arc for exploring most of the key climate and energy issues of our day. And it is told in a dispassionate way, grounded in facts and analysis. It’s not a heavy ideological push that is looking for facts to bolster it. It's quite the opposite. He's approached it like an engineer solving a big problem. And problems don't get much bigger than this. And the book follows, point A to point B. When you get to point B and you've heard the whole story, if you read it sequentially you may or may not agree with where Mark comes out. Personally I do, but you will have seen the argument laid out in straightforward detail, for any level of interest or understanding that you might bring to the book in terms of energy policy.

(00:03:46):

The book you want have for that purpose if you want to read front to back to understand our current energy, major questions, and solutions. But the second use of it, and I've already made use of it in this way, which is really as a reference book, because as you get a chance to look at it and open the table of contents, you can also, at any given time, dip into one of the chapters or one of the sections and get answers to all kinds of discussion, at least. You may not want accept it as an answer right away. I find it very compelling in that use. But you'll be able to use this book in a way that will help you navigate questions that come up. I mean, whether it's what's the role of rooftop solar?

(00:04:35):

What are the pros and cons? What's with nuclear power? How does it fit in or not fit into our climate solution set? Wind turbines and birds? It doesn't really matter what particular key hot topic you might pick. Mark has covered it in this book, and you can pull that out. Just like, you don't have to watch Game of Thrones beginning to end. You can watch individual segments, and it's very gratifying. This is Game of Thrones, does energy! Or that doesn't really work. But anyway, you get the idea. It's a fantastic book. I can't thank you enough for writing it, Mark. He is a Stanford University professor of Civil and Environmental Engineering. He's the director of the Atmos Energy Program at Stanford University, co-founder of the Solutions Project with my buddy and your buddy Mark Ruffalo, and of the hundred percent movement. And he is the author of the book we're talking about today: *No Miracles Needed*. There may be one or two miracles needed, but we'll get to those at the end. Mark, it's all yours. Thanks so much for writing this book, and thanks for joining us today.

Mark Z. Jacobson PhD, Professor, Stanford (00:05:49):

Wow. Thank you so much, Ken. That was such a nice introduction. Very generous. And Bart, too. Thank you so much for having me on here. I'm going to, share my screen and I'll start this talk. First, let's motivate why, I became interested in this. While I'm really interested in trying to address three problems simultaneously: there's air pollution, global warming, and energy and security. Air pollution has been around for hundreds, to thousands of years now. Actually since, really the dawn of civilization. But today it kills 7 million people each year, and hundreds, millions more are injured and based on statistical cost of life. It's on the order of 30 trillion dollars per year. Global warming is estimated to cost 30 trillion per year by 2050. And today you can already see damage that's accruing on a daily basis, while enhanced wildfires, enhanced air pollution due to higher temperatures, more droughts, more floods, more severe storms, more shifts in agriculture and losses in agriculture, higher sea levels, melting of ice, coral reef loss, and it goes on and on.

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The third problem is energy and security. And there are many types of energy and security, and I'll just touch upon them. You know, one is just, on the large scale, while the fact's that fossil fuels and uranium are limited resources. They will run out at some point, and that will result in economic, social, and political instability unless we have an alternative in place. In addition, many countries supply fossil fuels and control those fossil fuels to other countries. And so, in times of conflict, like as you see now, some countries can hold energy hostage to other countries. Similarly, just transporting fossil fuels long distance, like over the water to island countries, results in extremely high electricity prices up to 50 to 70 cents per kilowatt hour. And those island countries can be self-sufficient with just renewable energy. Anyway, there are other types of energies in security as well, but these are all three problems that we're trying to solve simultaneously.

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The thing is, I'm not going just look at solutions that solve climate. For example, they have to address climate and air pollution and energy and security, simultaneously. This is why some of the solutions that are discussed in the book and some of the solutions we do not include, which I'll discuss as well here.

They're not included because they do not address all three problems. Well, first of all, let's talk about what is the solution that we've been proposing since 2009. It's to transition or electrify everything. To electrify transportation, buildings, industry, and then provide the electricity with just clean renewable energy, namely wind, water, and solar. And we define wind, water, and solar as onshore, offshore wind, solar, photovoltaic on rooftops and power plants, concentrated solar power, geothermal electricity, also some geothermal heat, hydroelectricity, tidal, and wave power, even though those two aren't growing very fast.

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But there are other smaller ones that are, if they emerge, especially fine. But we're not going to use any combustion, for electricity or anything else. For transportation, we'd go almost entirely to battery electric with some hydrogen fuel sale for long distance transport, like long distance aircraft and ships, and maybe some long-distance heavy military vehicles. And all the electricity for both the hydrogen would be green hydrogen, and I'll discuss that in a sec. But where the, hydrogen's produced from wind, water, solar, electricity, and the electricity for the batteries would also come from wind, water, solar for buildings we use, we'd electrify those. No gas in buildings at all. Electric heat pumps for air and water heating and air conditioning, and also heat pumps for, clothes dryers, electric conduction cooktops for stoves, and I'll talk about buildings.

(00:09:57):

further. Some buildings will be on district heating systems like they are now, where you can not only use heat pumps to raise the temperature or lower the temperature for the boilers or chillers, but you can also use, geothermal heat for the district heating or large scale solar heating for that as well. For industry, we'd electrify that with electric arc furnaces, induction furnaces resistance furnaces, dielectric heaters, electron beam heaters. For steel production, for example, we would go to the hydrogen reduction process. So hydrogen would replace coal for converting iron oxide to a pure iron. Anyway, there's already a steel mill in Sweden now that's uses hydrogen, and the hydrogen is green hydrogen and everything else has been converted. So even the arc, they use an electric arc furnace as well. And that's provided with green electricity. And so there's 98% reduction of fossil fuels from that process.

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98% reduction of carbon emissions from that process. Anyway, there are solutions for cement, like using geopolymer cement instead of Portland cement, recycling cement. There are existing technologies. We have 95% of the technologies we need right now to effective transition. The ones we don't have are the long-distance aircraft and ships primarily in some industrial processes, but we know for the most part how to do that. And we expect that those technologies to be in place within the next five to 10 years. For storage: of course, the wind doesn't always blow, the sun doesn't always shine. There's electricity storage, heat storage, cold storage, and hydrogen storage that's needed. Electricity storage options: concentrated solar power, with storage, pumped hydro storage, existing hydroelectric dams or big batteries. Basically, batteries themselves. Flywheel, compressed air storage, gravitational storage with solid masses. These are all existing technologies and, you know, batteries are of course the most convenient.

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If their cost is now like a hundred to $200 per kilowatt hour, if it gets down to like $60 per kilowatt hour, then that makes it really easy to transition on a large scale economically. Even there are some batteries, or iron air, for example, it's been proposed that it's going to be $5 to $10 per kilowatt hour. If that actually works at that cost, that's even more amazing and we'll have an easy shift. Heating and cooling: for hot water and cold water, we'd have water tank storage, which is already existing in large scale. Ice storage for cooling. And then underground storage for bore holes, water pits and aquifers for mostly heat storage, but also cold storage and aquifers in some cases. Then building materials is a method of storing heat.

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Then of course, hydrogen. With respect to hydrogen, there are good and bad sources of hydrogen and uses. So I try to summarize what I think are good and bad. So the only good hydrogen I think is green hydrogen, which you produce from an electrolyzer running on wind, water, solar, electricity. Bad is gray and blue, which comes from natural gas without, and with carbon capture respectively. Black and brown hydrogen from anthracite and lignite coal. Pink hydrogen from nuclear electricity and turquoise hydrogen from methane pyrolysis. Those we do not recommend, but we have green hydrogen today, although 96% of all hydrogen produced today is gray hydrogen from natural gas. So now that green hydrogen is becoming less expensive, we need to shift away from gray hydrogen. Well, what about uses? Well, first I'll talk about what we don't want to use it for.

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It's not efficient to use hydrogen for passenger vehicles. It's clean if it's green hydrogen, you take need two and a half to three times the number of wind turbines to run a passenger vehicle on green hydrogen, versus a battery electric vehicle. So why waste so much opportunity with that? Heating buildings is not a good use of hydrogen. For example, utilities are proposing to put mixed hydrogen with natural gas instead of to buildings. Well, that just allows combustion and pollution to continue and natural gas to continue, in fact, whereas heat pumps use one fourth the energy as burning things. So those are the best. And we want go pretty much entirely to heat pumps for heating and cooling of buildings. We do not want burn hydrogen to the extent we can't, just use them in fuel cells, and in most cases, we don't want use it for grid electricity.

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Although in some cases it is advantageous. Batteries are a lot more efficient. The roundtrip efficiency of battery is much better than going from an electrolyzer to compressor to storage to fuel cell for grid electricity for hydrogen. There is some advantage in hydrogen in the storage cost is lower. However, you need batteries for two purposes. One is for storage and storage capacity, and the other is for peak discharge. To get the same peak discharge as a battery, you need a lot of fuel cells. Fuel cells are more expensive than batteries for peak discharging. When you actually look at it all, it's actually better, pretty much everywhere to use batteries. Although there's some situations where if you combine batteries with some fuel cells at a hundred percent near a hundred percent renewables on the grid, then it's a little bit cheaper when you combine the two.

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But in most places in the world, it's just using batteries alone is the best. So the good applications of hydrogen are long distance aircraft ships, trains, trucks, and military vehicles (and that's really long distance). For aircraft, it's greater than 1500 kilometers. About 84% of all flights by number are less than 1500 kilometers. Those would be electric. It's about 16% of the flights by number or about 46% of flights by distance, would be hydrogen fuel cell. Also, for ammonia production and steel manufacturing, we need hydrogen and electricity and heat for remote microgrids—combining, again, batteries with hydrogen fuel cells can actually help the remote communities up in northern Alaska, for example, provide electricity year-round. And as I mentioned, some cases of grid electricity, but not most cases now.

(00:16:21):

Okay, so why? Well, we do not include carbon capture, direct air capture, small modular nuclear bioenergy and non-hydrogen e-fuels or geoengineering is part of our solutions. First, I'm going to show you this photograph. I took the photograph on the bottom right about a week and a half ago in Los Angeles. You can see how bad the pollution is. In Los Angeles, millions of people live there. California's the most polluted state in the US. Over 13,000 people die of air pollution in California each year, and about 80,000 in the us. On the top left is a photo of Los Angeles from 1958. We have not come a long way. I mean, we have come a long way, and the peaks of air pollution are much lower. The peak air pollution, the record is in Los Angeles. I don't know if it's if anybody's measured any higher ozone in the world anywhere than in Los Angeles.

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It was like 980 parts, 980 parts per billion. The federal standard for ozone eight-hour standard is 70 parts per billion. So in the 1950s, there was a measure of 980. We don't get anything close to those peaks. There most you get is like 150, but it's spread out over a larger area. But you still have this pollution. We should not, this is all from energy almost. About 90% of all air pollution is from energy. About 75% to 80% of greenhouse gas emissions are from energy. This is just unacceptable. We need to stop combustion, stop burning things. It's from both burning of fossil fuels and biofuels, transportation, buildings, industry and electricity, and carbon capture, direct air capture, bioenergy, geoengineering and blue hydrogen, for example. They all increase air pollution.

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So why would we have something that increases air pollution? You might ask why. Well, carbon capture, for example, if you're putting carbon capture on a coal plant, 30% of the electricity from the coal plant needs to be used to run the carbon capture equipment. Or alternatively, you need to mine 30% more coal to run that carbon capture equipment. A carbon capture does not eliminate any air pollutant. It takes out carbon dioxide, which is not a standard air pollutant. It does affect air pollution indirectly through higher temperatures and water vapor, but it's not reducing any air pollutant. It's actually increasing air pollution, 30%. Then 75% of carbon dioxide that's captured gets shipped today worldwide for enhanced oil recovery through pipes. 40% of that carbon that is captured goes right back to the air during that process.

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It also results in more oil being burned and used. The efficiency of carbon capture equipment is not 90%, it's between 20% and 70% in the annual average based on actual data. You're not actually stopping any CO2, but from the mining and extra energy needed to run it, you're actually emitting more CO2 that has to be captured. So, when you actually count for everything, you're only capturing about 11 to 20% of the CO2 when capture equipment is added to a coal or gas plant. And that's before you even account for the enhanced oil recovery and you lose 40% there. So, you're really talking about 7% to 12% capture rate, which is useless. You're increasing air pollution. You're increasing mining of fuels. You're increasing fossil fuel infrastructure. Same thing with direct air captures. It takes energy and requires equipment.

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It only reduces CO2. So, because you have all that extra energy you're using, you're either running more fossil fuel to produce electricity to run the direct air capture and creating more air pollution. Or you're using wind and solar, preventing that wind and solar from replacing a coal or gas plant, which would eliminate the air pollution from that coal or gas plant. Now, you can't eliminate that pollution, so you're effectively increasing pollution too. Same thing with blue hydrogen, which is natural gas producing hydrogen with carbon capture. You need more energy. You need more natural gas to run that equipment that results in more air pollution. So, just to summarize, carbon capture, direct air capture, bioenergy too, because you're just burning a different fuel instead of oil or gas to produce electricity or run a car. Those all create air polluting carbon capture, direct air capture, blue hydrogen bioenergy, also non hydrogen electro fuels.

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Some people propose taking, for example, carbon dioxide and creating a fuel to replace gasoline. This is another hair brain scheme because you're still burning fuels to create air pollution. You need a lot of chemicals to create the fuel. You need a lot of energy, and you have to capture that carbon, which we just talked about was completely inefficient. And so there's no basis for that. The most commonly talked about type of geoengineering is dumping particles into the stratosphere to reflect sunlight first. That's also not helpful at all because it just allows emissions to continue air pollution to continue, makes people complacent and it costs money. It's an opportunity cost that doesn't solve any problem. It just masks a problem, and there's just all sorts of side effects that I can't get into.

All right, so I'm going to shift quickly to talk about what can you do in an individual home?

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I'm going to talk about my own home, just because I have some data from that. In 2017, I built a new home from scratch, no gas. All electric has, solar on the roof batteries in the garage, heat pumps. It's 13.6 kilowatts of solar. There's four, first generation Tesla wall mount batteries, 3.3 kilowatt discharge each. It's 13.2 kilowatts, total discharge and there's about two hours of storage. So, 26.4 kilowatt hours about of storage. For heating, I use what's called a ductless mini-split electric heat pump for air heating and air conditioning. So there's, there're no ducts, but you have inside units, like on the left in each room, and then you have two of these outside units. And so there're abouts five or six inside units connected to each outside unit, and they just exchange fluid, through a thin pipe.

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The heat pumps do not create heat or destroy it. They just move it around. They take it from the outside and move it in or take heat from the inside and move it outside. So because they're not creating heat, they are much more efficient than gas or even electric resistance heaters using one fourth, the energy, so it uses hardly any energy. Same with the water heater. This is a heat pump water heater. It's just plugged into the wall. It has some pipes for the water, but there's no natural gas pipes. And in fact, I saved a lot of money by not putting natural gas in the home. I saved a $6,000 hookup fee. I saved about $10,000 in pipes. This heat pump water heater uses one-fourth the energy as a natural gas heater and it works really well. It has not had a single problem in the last six years. For cooking: an induction cooktop, which boils water in half the time as natural gas.

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Even when you're boiling water and you touch the stove, it doesn't hurt because you're not actually heating the stove. You're, it's just due to the electrical resistance in the pot. It has to be an iron or stainless-steel pot (something that is resistive), and the electric currents in the induction cooktop will induce currents in the pot. And due to the resistance, those currents in the pot dissipate to heat. So the pot heats up but the stove does not, and it cooks really evenly. I show this one on the left because you can buy one of these for like $30-$90.

I mentioned 7 million people dying from air pollution. Well, about 2.4 million people each year die from indoor air pollution, from indoor burning of biomass and coal for home heating and cooking (mostly in developing countries). Just by replacing a wood burning stove or dung burning stove with an electric resistance, you can eliminate most of the air pollution in a home.

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But of course, you need electricity source, and so we do need to transition. There are a lot of places that do not even have electricity. So, having microgrids that run on solar batteries and electrical appliances and through a community is an important part of the transitions. transitioning everywhere, not just here. It's a worldwide transition, which I'll get to in a second. Well, after the first five years, I generated 120% of all my home and vehicle electricity needs. I have electric vehicles too. No electric bill, no natural gas bill or gasoline bill. And received an average of $860 a year from Silicon Valley Clean Energy, which is the community choice aggregation utility that I've signed up with. They take the extra electricity. The numbers below that show kind of typical values for a, for a home, um, that you would save.

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I avoided $6,000 in gas hookup fee. The range is $3,000 to $8,000 for gas pipes. $2,000 to $15,000 is the range for electric bill, natural gas bills, vehicle fuel bills. On average it's a total of $5,000 to $23,000 upfront, plus $3,000 to $10,000 per year in savings. In my case, I have had a five-year payback time. I've already paid back the whole solar and battery system, but that's with subsidies offered by California in the US. Without subsidies, it would be about 10 years, but the solar is warrantied for 25 years.

One more point about this: this is some data from the hottest day of the year in 2020 September 6th. The green is my solar production. The blue is the consumption during the day, mostly for the heat pumps for air conditioning.

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There's 106 degrees outside and inside of maintaining the temperature at 77 degrees. During the day, it's directly from the solar. After the sun goes down, it comes from the battery, and then the red is grid electricity. But on that day, as you can see on the top right, I actually, produced 14 more kilowatt hours than it consumed over the whole day and sent the extra back to the grid. And this was a day where people were prone to blackouts in California. If everybody did this, we would have no blackouts on the grid. If all buildings had solar and batteries, there would be no blackouts because we'd be using a lot less energy. Heat pumps are so efficient, they hardly use any energy for keeping a building cool. We have a lot of solar in California, but we also have potential for a lot of offshore wind.

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Even when the sun goes down (a lot of times blackouts occur right after sunset), we can fill in that gap after sunset with offshore wind, if we actually can grow that offshore wind. Now a stumbling block to that growing is that there's one big transmission line to the coast in California, and that's the one that goes to Diablo Canyon. So by keeping Diablo Canyon open, that's actually slowing down the growth of offshore wind right there, because it's very difficult for a company to build an offshore wind farm when there's no transmission to the shore. So, it'll take a while to get more transmission. This is a problem keeping Diablo Canyon open. Next question is, can the world transition to a hundred percent renewables for all purposes? We developed roadmaps for 145 countries and also separately did all 50 US states.

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Just to summarize on these roadmaps, these countries represent 99.7% of all world emissions for 145 countries. So in 2018, the end use demand for these countries was 13.1 trillion watts or terawatts. That's expected to go up to 20.4 terawatts. And this is for all energy purposes, but if we electrify all energy and provide the electricity with wind, water, solar, we go down to 8.9 terawatts or 56.4%. And that's for five reasons here. One is the efficiency of battery electric and hydrogen fuel cell vehicles over internal combustion engine vehicles that accounts for 20.5% of the reduction. Electrifying industries, 4.3%. The efficiency of heat pumps is 13.6%. Eliminating fuel mining, I mean, 11.3% of all energy worldwide is used to mine transport and refine fossil fuels and uranium. We would not need that energy if we don't use those fuels.

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Then 6.6% is due to induce energy efficiency improvements in reducing energy use beyond what's expected in a business-as-usual case. So that adds up to 56.4%. This graphic shows the same thing, but it's a timeline going from 2020 to 2050. If we don't do anything, we go along the top line. But if we electrify and provide the electricity with wind, water, solar, our energy consumption or requirements go down significantly by those five shades of colors down to a hundred percent WWS line, and for the five reasons I mentioned. Then we're left with 8.9 terawatts that we provide with just wind, water, and solar. This graph shows an 80% transition by 2030 and 100% by 2050. We would need that transition if we want CO2 in the atmosphere to go down to 350 parts per million by 2100.

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But if we can transition 80% by 2030, we should be able to transition the rest soon after. This graphic shows a transition timeline with the same end point in 2050, but a hundred percent transition by 2035. So, this is 80% by 2030 and a 100% by 2035. This is what I think we really need and we can accomplish if we actually put our mind to it. But of course, social and political barriers may slow that down. In this, we develop individual plans for the 145 countries, and this shows the average of, the wind, water, solar distribution over those 145 countries under the world column. So a 32% onshore wind, 13% offshore wind, 16% roof PV, 30% utility PV, 3% CSP, less than 1% geothermal electricity, 5% hydroelectricity, tiny amounts of tidal and wave, and some geothermal and solar heat.

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Of course, there are many options. I mean, this is not the only, possibility. I mean, there could be more rooftop solar, less utility solar, more offshore wind, less onshore wind, etc. Plus, a lot depends on how the prices work out. In the US I show a distribution, there too, which I'll talk a little bit more, later. But in terms of land use, this is for new land. We don't need any new land for offshore wind or tidal or wave power. We're not adding any new hydro in any of these plans. Rooftop PV does not take up any new land. There's very little geothermal. So the new land is mostly utility PV plus CSP and onshore wind. In the case of the PV plus CSP, that's actually what we call footprint on the ground. Although it doesn't have to be.

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Some we can actually put offshore, PV now, or on reservoirs, or we can elevate it above the ground over agricultural fields. It doesn't have to be footprint on the ground, but let's just call it that for here. Onshore wind, which is really spacing between wind turbines that can be used for agriculture, open space, farmland, range land. For the world, the total footprint area is about 0.17%, and the spacing area is 0.36%. So that's 0.53%. That's like half a percent of world land in the us it's 0.84% for comparison. In the us the fossil fuel industry occupies 1.3% of all US land area. If you count for the 1.3 million active oil and gas wells, the 3.2 million abandoned wells, the millions of miles of pipelines, the hundreds of thousands of gas stations, the storage facilities, the refineries, the coal mines, et cetera.

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We think we would reduce land requirements. Plus, with fossil fuels, there are 50,000 new oil and gas wells drilled every year in North America alone. Once you have a wind water, solar infrastructure that increases each year are relatively minor because we're not continuously mining for fuels. The wind comes right to the turbine, the solar comes right to the panel.

Can we keep the grid stable? We did grid stability studies in 24 world regions, encompassing all 145 countries and found that we can keep the grid stable, at a 32nd resolution. So we had wind and solar data for every 30 seconds throughout the world and combine that with energy demand data and with assumptions about storage and demand response. We found that we could keep the grid stable every 30 seconds everywhere in the world.

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What this graph shows is that for the US for two years, every 30 seconds, but this show's an hourly resolution of the graph. Then on the bottom graph, that's for a hundred-day period just showing the matching of supply with demand. Red is the energy supply and the blue is the demand plus changes in storage, plus losses, plus shedding. So what's the cost of keeping the grid stable? Well, worldwide, the capital cost was about $62 trillion. In the US there's about $9 trillion, and in China about $13 trillion. And that translated to the cents per kilowatt hour that you can see there. But what's really relevant is what's the annual cost and how does that compare with fossil fuels? Right now, fossil fuels cost the world about $11 trillion per year. That's expected to rise to about 17.8 trillion per year by 2050.

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The health cost of fossil fuels are about $33.6 trillion in 2050, and the climate cost are about $32 trillion. That adds up to a social cost of $83 trillion per year. Meanwhile, if you transition to wind, water, solar, you eliminate health costs associated with energy, you eliminate climate costs associated with energy, and you also reduce your energy cost 63% because you have a 56% reduction in the amount of energy you need. Then there's another 10% or 15% reduction in a cost per unit energy. That gives you a 63% reduction. So, there's a 63% reduction of energy cost and a 92% reduction of social cost, which seems to be a no-brainer why there's no reason why we wouldn't want to transition. Okay, so the final section I want to talk about is policy. In 2009, I mentioned, well, we developed our first energy plan to transition the world to wind, water, solar.

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It was a worldwide plan, but it did not involve individual countries, so it couldn't be effectively implemented. The conclusion of that study was, well, yes, it's technically economically possible to transition by 2030, but there are social and political barriers. So a more likely or more practical transition might be 80% by 2030 and a hundred percent by 2050. Little did we know that this turned out to be the scientific basis for the Green New Deal. Although there's no Green New Deal that has been passed at the US level (at the federal level), it was proposed in Congress. But it was never voted upon. However, there are 62 countries around the world who've committed to a hundred percent renewable electricity and only one country,

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Denmark, is committed to a hundred percent renewable energy across all energy sectors. Most of these are small countries. Although, there's Germany in there too, and Denmark. China represents about 30% of all world emissions. It's emissions are equivalent to those of about 120 countries combined. Then the US has a huge amount of emissions, and then there's Europe, the European Union, and India and other big countries. So we really need all countries acting together to solve this problem. We can't have just a few countries—it's particularly small countries. That's of course that's beneficial to do it in those countries, but that's not enough. We can't become complacent because a few countries have committed to do this. We really need all countries, including the biggest ones. Now, some good news is, there are 16 countries and states that are near or above 100% annual electricity generated or consumed from wind, water, solar. For example, Iceland, Norway, Costa Rica, Paraguay, Albania, Bhutan, Nepal, Ethiopia, and the Democratic Republic of the Congo, all generate their electricity—

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About 100% of it is wind, water, solar, with mostly hydro. You can see the 'H' means hydro. G means geothermal. W means wind. Kenya, Tajikistan, and Namibia, they're above 91% wind, water, solar in their generation. But the only one of that whole group that its major source is not hydro, is Kenya with geothermal as the major source. However, if we look at the US there are actually three states that have a lot of wind, water, solar as a fraction of their electricity consumed. South Dakota actually produces 120% of its electricity with just wind and hydro, with 77% being wind and the rest being hydro. It also produces fossil fuels. So it produces about 200% of what it consumes and it exports the rest. But the point is, of its consumption, over 100% is wind, water, solar.

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In Washington state, it's about 98.5%. In Montana, it's about 91%. Scotland consumes and produces the annual average. Over 90% of it is consumed energy. In the US there are now 19 states and territories that have laws in the electric power sector to go to effectively 100% renewables, although some of the wording is different to allow what they call zero carbon sources if new renewables are not there. There's only one by 2032, which is not a state: Washington DC; Rhode Island by 2033; Connecticut, Minnesota, New York, Oregon by 2040; Hawaii, California, New Mexico, Washington State by 2045, and then the rest by 2050. Finally, or almost finally, there are 180 cities in the US and counties that have committed to a hundred percent renewables.

(00:39:22):

The Sierra Club really took the lead on this to go to these cities and do grassroots movements to get a lot of these cities to commit to a hundred percent renewables. That was amazing. But many other nonprofits have, helped along with that as well. There are over 400 companies, or around 400 companies now that have committed to 100% renewables across their global operations, including eight of the 10 biggest companies in the world. And they're listed here. We also calculated worldwide we'd create 28 million more jobs than lost. These are long-term full-time jobs. In the US would be about 3 million. We'd require only 0.17% of the land for footprint and 0.36 per percent for spacing. We'd avoid up to 7 million air pollution deaths per year slow than reverse global warming.

(00:40:13):

We think we can keep the grid stable throughout the world with a hundred percent. The absolute energy costs, which are annual energy costs, are 63% less than with fossils. But the absolute energy health and climate costs are about 92% less. Finally, if you want more information, here's some links including the book that was mentioned earlier, and also our energy plans, which you can actually look at each country or state and there's an actual separate document for each country and state of how to go to a hundred percent wind, water, solar. In fact, if you go to that infographic map near the bottom, there's actually a map you can click on a state or a country or a city to get a plan. Then there's also this online course that basically summarizes a lot of stuff in the book. Anyway, I'm happy to answer questions and thank you all for listening.

Ken Cook, President & Co-Founder, EWG (00:41:06):

Professor, that was a tour de force. Thank you, thank you so much. I'll just remind people who are, in the webinar to type your questions into the chat and we'll pass them along. I'm going to kick off with a couple of them. A reminder the book is called *No Miracles Needed*, by Dr. Jacobson. It's got a forward by Bill McKibben, and a nice blurb on the front from Mark Ruffalo. Mark has been deeply involved in energy, equity and sustainability for many, many years, and has partnered with Mark on more than one occasion to promote that goal. So many questions that come up, but so many answers. Let me just start again with my reference book pitch here that you get in a debate over, nuclear power, payback periods for electric panels, even basic things like definitional matters that, have to do with energy. All in this book, you can just go right to the appropriate section and you get a very crisp fact-based analytical take on it.

(00:42:20):

But a lot of this started, you have to read into the book a little bit, from your experience as a tennis player. Your emphasis on air pollution to me really does my heart good. I think you could argue that one of the few environmental laws that really is regularly working in this country is the Clean Air Act. I consider it the queen of environmental laws. I was raised by two women. So that's the direction I naturally go. The focus on that in your analysis as the start of it, that's how you start the book, really is key. But this started when you went on a tennis tournament. That was your first impression with the choking, polluting power of air that, does end tens of thousands of lives prematurely in this country and, and millions around the world every year. Tell us a little bit, how did that stick with you as an engineer to be focused on environmental health? I salute you. It's really impressive to start the argument there.

Mark Z. Jacobson PhD, Professor, Stanford (00:43:26):

Well, it's interesting because when you live in pollution, you don't notice it. But when you live in somewhere that's cleaner and then you go to a polluted area, you do notice it. I mean, I grew up in the San Francisco Bay area, and it was polluted here too, but I lived in it, so I didn't notice it. But I remember going to San Diego first to play in a tournament, and I could not believe it because just driving on the freeway, it was just scratchy eyes, couldn't see, smells, you know, and starting to cough and stuff like that. And it was just like, this was obnoxious. I just thought it was horrible. I took another trip to Los Angeles, same thing. So things have gotten better, but as I showed in that photograph, they're really still pretty bad. We should have blue skies everywhere and that's the goal. This is why we do not want to burn things. We do not want to go to alternatives that allow combustion to continue.

Ken Cook, President & Co-Founder, EWG (00:44:21):

Yeah, absolutely. I mentioned very briefly that there might be one miracle we need and that miracle, generally speaking, is political will. We need to develop that. And I happen to think that your book provides the scaffolding on which political will can be built if people just read the book and understand the analysis in it and the takeaways that make it very clear that this is right in front of us now. This is not something that we should be necessarily thinking as a century away. These technologies are here. The price drops on so many of the components of the energy system you're describing from solar panels to batteries, to all manners of advances in electric vehicles. When you talk about this to a skeptical audience that might raise questions about how we're going to make the transition, what are some of the main points of opposition that you notice Mark, coming from people about skepticism about your thesis and the arguments you lay out here?

Mark Z. Jacobson PhD, Professor, Stanford (00:45:33):

Well, initially it was we can't keep the grid stable with renewables. In fact, utilities would say, in fact in 2009, they were saying, oh, we can't have more than 20% renewables on the grid without it crashing. And that eventually got blown away with more examples coming. 5-10 years later. There are more examples of higher penetrations beyond 20% throughout the world. In fact, I think by 2016-2017, the bar, had been raised to 80%. A lot of scientists and utilities are saying we can do 80% now, but we just can't do 100%. <laugh>. It used to be we can't do more than 20%. Now we can't do more than 80%. And what was the reason they said we can't do it more than 80%? It was just, well, we need nuclear, we need carbon capture. It was more because we needed to use something else rather than we couldn't do it.

Ken Cook, President & Co-Founder, EWG (00:46:24):

That's right. Yeah.

Mark Z. Jacobson PhD, Professor, Stanford (00:46:26):

Then it suddenly changed to, oh, well it's just more expensive to do it with 100% renewables. It is just continuously changing. Well, it's good that it's actually changing. If it's debate between whether it's 100% versus 90%, at least that's moved, but moved it a long way. But, you know, there is no barrier. As I said, there are 10 countries that are a hundred percent renewables. I mean, granted it's by hydro, but take South Australia. The two most reliable grids in Australia right now are one in Tasmania, which is dominated by hydro and two in South Australia, which is 70% wind and solar. So right there is an example of hugely dominant grid that's wind and solar that's actually more reliable than the other grids as just came out in an article last week.

Ken Cook, President & Co-Founder, EWG (00:47:14):

Let's pick on a couple of common topics on the energy landscape, because you've written about all of these in your book and in your flood of research and studies that I think all of us in the public interest community who are working on clean energy, Mark, lean very heavily on your research and analysis, you and your team at Stanford. So I again, thank you for that. And I also want to add my thanks to all of the great groups that Bart mentioned at the top of the call. You know, without them and groups like them, Tesla wouldn't exist. The renewable and the electricity standards, the goals at the state and city level—this is civil society making this happen. But there are some big fights out there and we just had a new wrinkle in one of them yesterday with a green light from the nuclear regulatory commission to extend the license at Diablo Canyon. Without going into all the details, say a little bit about why the arguments that we must have nuclear as a key feature of our energy future if we're concerned about climate change. Why that doesn't really pencil out?

Mark Z. Jacobson PhD, Professor, Stanford (00:48:36):

Well, separate between new nuclear and existing nuclear. If we start with new nuclear, there's two plants being two reactors being built in the US. They're in Georgia and the vocal plant, the same location, they're on years 17 and 18 between planning and operation and they're still not running. They've cost $34 billion so far for 2.2 gigawatts. That's $15.20 a watt compared with $1 a watt for wind or solar. Even if you look at the energy cost counting for the capacity factors of it to, it's about 7 to 8 times more expensive from that plant than new wind or solar. Rooftop solar you can put up in six months between planting and operation, but utility scale one to three years.

(00:49:29):

So would you wait 17? And by the way, that's not the only plant. I mean, in Europe we have Flaman Ville, Olkiluoto, Hinckley, they're all taking between 17 and 21 years between planning and operation. So do you want to wait basically 15 to 20 years longer for a technology that costs 7 to 8 times more per unit energy? It just makes no sense. It's 2023, we need to solve 80% of the problem in 7 years. We can't have a technology that if you start planting today will be available in 2040 at best. It's useless On top of that, to build that nuclear plant, they've already laid enough concrete at Vogel in Georgia for a sidewalk from Miami to Seattle. They've put in a lot of CO2 in the atmosphere and not a single bit of that CO2 has been removed due to running that nuclear plant.

(00:50:23):

And it's still not going be removed for a while because they have to keep delaying when it's ever going to start. So, there are emissions associated with it and there are opportunity cost emissions. While you're waiting for that nuclear, you're running the regular grid which has coal, oil, gas on it. You have to account for that opportunity cost emissions versus solar wind. You have to account for the fact that you have to continuously mine and refine uranium, which takes energy and there CO2 emissions associated with that. You have to account for the heat emissions from the nuclear plant, the water vapor emissions from the nuclear plant. When you account for all those, you get nine to 37 times the CO2 emissions per kilowatt hour compared with new wind. So I mean, even though it's better gas, I mean natural gas is a lot more emissions, but it's not as good as wind or solar from either emissions point of view, cost point of view, or rapidity of getting it in action.

(00:51:12):

That doesn't even account for the fact there's weapons proliferation associated with nuclear. There's meltdown risk. One and a half percent of all nuclear reactors have melted down. There's underground uranium mining. 10% of uranium miners historically have developed lung cancer died from the radon that's resulted the cancer that resulted from polonium from radon decay. There's there's a waste issue. You have to store 200,000 years of waste or waste for 200,000 years. So, there's all these problems. You don't have these problems. So they're energy security problems with it that you don't have with wind, water, solar. Now we've been told that small module reactors will approve this. There's no evidence of that. They don't even plan to be available until 2030. And that would just be some test reactors. And who knows since that has already been delayed two years.

(00:52:02):

The cost already escalated three times the original estimate. They're still going to have the cost problem. They're still going have the delay problem. I still have to remind that uranium is still a problem. Some say they don't have as much waste, but that's because they're refining closer to weapons grade uranium. So it's more of a security risk. These small modular reactors will be shipped around the world, you know, so they'll go to more countries that will secretly develop weapons under the guise of civilian nuclear energy programs. The small module reactors is no good. What about existing reactors? Well, if they don't require subsidy. You know, New York has three upstate reactors that required 7.8 billion of subsidy to stay open an extra 12 years. After that you have to still build the wind and solar.

(00:52:51):

You have to spend another like 10 billion after that. So it's 17.8 billion. Why not just spend the 10 billion right now on the wind and solar and you don't need the subsidy? Makes no sense. In fact that we did a calculation and it made no sense. It was cheaper to build the wind and solar, faster and then retire those plants. That's what they should have done with Diablo Canyon. California has the potential to be a hundred percent renewables very quickly. It's already around close to 50%. I mentioned before there's this big transmission line to the coast that Diablo Canyon is hogging. It's preventing offshore wind from going up there. So there's already 1.4 billion of subsidy going into Diablo Canyon to keep it open. But that's just the tip of the iceberg, I'm sure.

(00:53:37):

We need to just rapidly transition away to renewables without getting distracted. If it didn't cost anything to keep Diablo Canyon open, then there's the other problem. There's a law that actually required it to have new cooling towers, which would've cost 9 billion to 14 billion to install. That's why it closed initially, but they suspended this law. You know,there was a reason for that law. All coastal plants had to have it because there's a lot of fish kill off. So they suspended the law and they've given them subsidies. There's two subsidies they've given to this reactor to stay open. Whereas California has the potential to go all the way renewables and keeping that open is completely slowing it down and preventing the rapid transition that we need. So anyway, I think I've said a lot about that.

Ken Cook, President & Co-Founder, EWG (00:54:23):

No, no, thank you. I wanted you to go through it and it's also beautifully laid out in the book on all of these points because, time and again, a lot of folks run into these arguments in the wild. And your book is a great resource for brushing up on the key elements of some of these old approaches, and all-of-the-above. I was so glad to see you bash the all-of-the-above thinking that is still unfortunately dominating energy debates here. And I'm referring to the idea of 'let's just fund everything'. Let's keep nuclear going. Let's build more gas pipelines. Let's have some solar on this side and some wind on that side. It's just, it's the absence of thoughtful decision making and political will that informs all-of-the-above thinking. I just think your book's invaluable in penetrating that myth too.

Mark Z. Jacobson PhD, Professor, Stanford (00:55:21):

All-of-the-above is a bad policy because maybe 20 years ago when there was a lot of uncertainty about these technologies, but we know what's working right now, and we know what's being implemented and can be implemented. We know what we need to do to solve the problem. So why are we wasting money on things we know are not going help either? Not going help at all or going to make problems worse. Part of this is because of this: I think this mindset some people are only looking at climate and they're ignoring security or air pollution. And when you do that, yeah, I agree. You can come up with different technologies, then the fossil fuel industry is making their own proposals to stay alive and they have a lot of lobbyists so they can influence academics too, to give them research funds.

(00:56:10):

In fact, they do that at my own university. ExxonMobil has given a lot of money to researchers to study carbon capture and natural gas. There's a whole group called a natural gas initiative at my university. It's kind of ridiculous, but other universities are polluted by this as well. The fossil fuel funding of universities to perform research, then those researchers go out and say, 'oh yeah, we need more funding for this. We should be subsidizing these things'. That's why the Inflation Reduction Act is now a replay with a bunch of useless subsidies for carbon capture, direct air capture, blue hydrogen, small modular reactors, bioenergy. I'm surprised it doesn't have geoengineering in there too. <laugh>, it's probably squeezed in there as well.

Ken Cook, President & Co-Founder, EWG (00:56:58):

It's tens of billions of dollars devoted to those losing, propositions from the standpoint of the future I think all of us want, which is clean energy, less, less pollution, less death. Let me bear down on another issue. First of all, just to make a note of, and I'd love your thoughts on the difference between the auto industry that seems to be pivoting to electric. Basically, once we get the supply of electricity cleaned up, it'll be a terrific and fairly swift transition, whereas the power sector is clinging, it seems, because of their business model, to some of these old capital intensive approaches, which is how they make their money investing in infrastructure to build out the grid. They even make money cutting down burned trees <laugh> when they've caused a forest fire here in California. How do you explain how the utility industry can be moved in some of these issues? We have labor unions who want the big centralized power plants to continue. They want Diablo Canyon, they're all about that. What’s your sense of the kinds of arguments we should be using and the kind of points we should be making in the policy sphere to counter that?

Mark Z. Jacobson PhD, Professor, Stanford (00:58:22):

Well, I think the reason there's a difference is because the auto industry relies on sales of new cars to keep in business. So they have an incentive to build cars that people want and that are efficient, and they have no reason not to go to energy efficient or electric vehicles. Whereas the utilities, if they own a coal plant that's grandfathered in under the Clean Air Amendments, it doesn't need to, emission control technologies is costly, two or 3 cents a kilowatt hour to operate. They have no incentive whatsoever to go out of business. So the first thing is, we need policy makers to get strong and make them pay for their pollution and make them upgrade. That will force them out of business or force them to do something different. So, it's really an incentive system with regard to the utilities.

(00:59:09):

That's why it's helpful to have these a hundred percent laws, these renewable portfolio standards. Those renewable portfolio standards—a mandate to go to a hundred percent really requires a phase out at some point. Now, having said that, I will note that many of the states in the US that do not have any hundred percent laws are actually leading with wind and solar because it's so inexpensive. In fact, nine out of 10 states with the highest fraction of their electricity from wind are all states that do not have policies to go to a hundred percent renewable. They're all basically red states. And why is because wind is so cheap. Same thing with solar. That's two ways you can motivate a transition is having really low cost energy from wind and solar. The other is to have strong policies to incentivize the transition or to require a transition. But I think you need both. These policies are really necessary to speed things up; otherwise, they'll just drag for a long time.

Ken Cook, President & Co-Founder, EWG (01:00:05):

That's for sure. Well, we're coming up on the hour, I think Bart. So I'm going to come to you. Several people have raised their hands, but I can't call on you. So if you didn't put your questions in the chat, quickly do it if you can. Well as Bart said, that'll be available later. I just wanted to turn it over to you, Bart, for any thoughts you might have, and then we can go to Mark for closing thoughts.

Bart Ziegler PhD, President, SLF (01:00:31):

I'm astounded at what you two have put together, and so I'll hold up my copy that I've only read through once that needs a couple of reads. But back to the unreveal, we have a couple of questions I'd like to add, Ken, if you don't mind. We have a couple of questions about lithium and one is from Cathy Iwani. Can you comment on what your vision of the future of the world's precious resources, lithium and cobalt, how can we supply the grid sustainably when the world's lithium reserves are limited?

Mark Z. Jacobson PhD, Professor, Stanford (01:01:08):

Well, with known reserves of lithium, there's enough lithium for, I think like 10 billion vehicles and there are about 1.4 billion vehicles in the world. Having said that, lithium batteries can now be recycled and lithium can be recycled. In fact, there are companies like Sonin who recycle 100% of their batteries. There's Redwood Materials as a spinoff of Tesla that they recycle 97% of all the materials in batteries and also solar panels as well. Also there's one estimate that the Salton Sea alone contains enough lithium for 40% of all world lithium needs. Right now in the Salton Sea, there are geothermal electricity plants that pull up the brine and extract the heat from that. You can take from that same brine; you can take lithium.

(01:01:59):

In fact, there's a project to do that. And so there's no additional mining at all. With regard to cobalt, there are batteries, like one of the Tesla, I think it was Tesla model Y doesn't even use cobalt in its batteries. So there are batteries, I mean there's lithium iron, iron phosphate or something, that do not have at all. So there are other possibilities for batteries. But in terms of overall mining, we'll need materials for a transition, but we do not need the continuous mining of fuels. And when you look at the mass of fuels that are mined continuously, as I mentioned earlier, 50,000 new oil and gas wells drilled every year in the North America alone. But worldwide, there's analysis of how much material is mined every year.

(01:02:46):

And you compare that and you add up that material for fossil fuel consumption. You add to that all the materials used for all the metals used, and then you compare that to the metals needed for a transition. We're talking like much less than 1% of the current mining would go on, annually. So it's really a red herring, the whole mining issue in terms of what people are bringing up. 'Well, you'll need so much material'. That's not what this question was about, is just about lithium, which I think I answered. But I do want answer that question because a lot of people are concerned about will we just be mining something else? And lots of it compared to what we're mining today. No, we're going be mining at least two orders of magnitude less than what we're mining today.

Bart Ziegler PhD, President, SLF (01:03:32):

Well, in line with that, with the battery problem or question, Jeff Severinghaus says, 'Fantastic presentation. What do you think are the big barriers to grid scale battery storage? You mentioned iron air batteries. Can you elaborate on those?' And to the same vein, we have Gordon Edwards saying, 'I am interested in district solar heating using seasonal storage. For example, huge water filled abandoned grain elevators'. He's from Canada. We want to make sure that we take care of our Canadian partners.

Mark Z. Jacobson PhD, Professor, Stanford (01:04:04):

I'll talk about the district heating first. Yeah, district heating is great. So there's underground storage and boreholes, water pits, and aquifers. Water pits is like basically a big swimming pool. You have a lot of water, and you have solar panels in the summer or solar thermal panels to heat up the water, and it's insulated and you store that heat. I think it's up to 80 degrees Celsius through the winter. Now, if you have a big grain silo, yeah, you can do that on a smaller scale. I don't know how much water you can put in that silo, but in any water tank you can store heat. You can store it in grained or you can start in soil or grain. There are actually modular materials now that you can purchase, where you can store heat in.

(01:04:51):

So instead of having to like put boreholes underground, which is, you know, that's a big project, you can actually purchase some material that you can store heat in that will last for a while. But the nice thing about that underground borehole storage and also the water pit storage is it's dirt cheap. Excuse the pun, but it's less than $1 a kilowatt hour of thermal energy storage. Now batteries, even though it's not the same (electricity is different from heat), there are a hundred to 200 a kilowatt hour. So it's really inexpensive storage. And sorry I missed what the first question was.

Bart Ziegler PhD, President, SLF (01:05:26):

We have over a hundred questions.

Ken Cook, President & Co-Founder, EWG (01:05:34):

I'm just now on the question page. I'm so sorry.

Bart Ziegler PhD, President, SLF (01:05:38):

Maybe you could talk a little bit about hydrogen. I have a number of questions about hydrogen. It's from Jill Rogers and Kurt Anderson. Green hydrogen versus blue hydrogen, and the barriers to using hydrogen. What do you think, Ken?

Mark Z. Jacobson PhD, Professor, Stanford (01:06:00):

Blue hydrogen we don't propose using at all because it's just natural gas with carbon capture added. It's just already the natural gas production of hydrogen you need to mine the hydrogen. 60% of all natural gas in the US is mined from with fracking. And then you have pipes, so you have leaks of methane upstream. Then you'll need more natural gas to run carbon capture equipment. That means more mining upstream, more leaks upstream and nothing's captured there. Then you have capture equipment that's inefficient at the capture plant. So you don't have to capture all the CO2, but you have more air pollution because you need more gas. Then you have to build more pipes to send CO2 somewhere else. It's usually going to enhanced oil recovery, as I mentioned,

(01:06:47):

and you lose 40% of CO2 from that process. The whole thing is just so complicated. You can just have a solar panel producing electricity, run through an electrolyzer to produce hydrogen, and you've got it. You don't have to have any pipes for anything. You should produce the hydrogen on site, like at a steel factory or ammonia factory, or at an airport where you might need it for long distance aircraft. So you don't even need to transport the hydrogen in that case very far. And in fact, now there are even photo cells that you can produce hydrogen, where there's a solar panel that the electrolyzer is actually built into the solar panel. It's one device that can produce hydrogen. Now compare that with that whole infrastructure of mining natural gas pipes, storage facility for the natural gas, the SMR (steam, methane, reforming) plants, more carbon capture equipment, CO2 pipes. And you have to do something with the CO2. Compare that with just one simple device that produces hydrogen from this one panel that produces electricity and the same device produces the hydrogen. It just makes no sense to go further down that route. But having said that, 96% of all hydrogen is produced from natural gas today.

Ken Cook, President & Co-Founder, EWG (01:08:03):

Will people be able to get the slide presentation?

Mark Z. Jacobson PhD, Professor, Stanford (01:08:12):

Yes. I'll send them.

Ken Cook, President & Co-Founder, EWG (01:08:13):

This presentation will be recorded and available on various platforms. We have time for a few more.

Ken Cook, President & Co-Founder, EWG (01:08:45):

Thank you for your valuable time. Several people asked variations on what the main barriers are to moving towards green hydrogen at this stage. What's your sense of that Mark? Are they mainly policy?

Mark Z. Jacobson PhD, Professor, Stanford (01:09:07):

There are electrolyzers being built around the world now, large ones, in fact. Certainly subsidies help. And I think in the Inflation Reduction Act, there are subsidies for green hydrogen. I think that has helped and will help promote it. But you do need a demand for the hydrogen once you produce it. So you have to know what you're going do with it, because otherwise you're going invest in a bunch of production and not have anything to do with it. I think it would be ideal to have simultaneous plans, like to go to ammonia where this hydrogen is used instead of fossil fuel ammonia. Also, for steel production, so have steel plants that are transitioned. Also, for some long-distance transport, like long distance aircraft and ships.

(01:10:01):

Just the other day, a 40-passenger plane was tested with one of the engines running on hydrogen fuel cell, being a hydrogen fuel cell engine. It worked perfectly well. So that's a good sign. There have been smaller hydrogen fuel cell planes, but that's a 40-seater, which is pretty big. Transportation ships, there are ferries--I think Norway today ordered two ferries that are hydrogen fuel cell ferries for its longest ferry paths it needs. So having demand simultaneously is going help. Otherwise, I'm not sure what there are any major barriers. Certainly, having costs come down even more will help.

Ken Cook, President & Co-Founder, EWG (01:10:43):

Someone mentioned: what role you might see for placing a price on carbon? Presumably a price that's high enough on carbon emissions that it would drive polluters to other technologies. What's your sense on that? Just from working in Washington, I know it's been a non-starter to try and get a working majority and support of that kind of policy. But what's your sense Mark?

Mark Z. Jacobson PhD, Professor, Stanford (01:11:19):

Well, I think it's easier for people to be for something than against something. So being for a hundred percent renewable energy, for example, that has a lot of popular support. I think over 80% of people support that. Then by being for 100% renewables, you accomplish the same thing as a carbon tax because in fact I think it's even more efficient. Carbon tax is one policy, but even if you tax carbon, it doesn't stop people from polluting. People might pay the taxes still pollute. That's why even a hundred percent renewable standard is better, because once you get to a hundred percent renewables, if they're clean renewables, that is, then you don't have any more emissions and you know that for sure. But if carbon tax allows the fossil fuel industry to say, 'we're going to use carbon capture, we're going use biofields, we're going to use direct air capture. That's how we're taking carbon out of the air. So we have effectively canceled our carbon emissions'. You can use all sorts of gimmicks to get out of a carbon tax too. Whereas going to a hundred percent renewables prevents that from happening because we actually do transition to 100% renewables without continuing fossil fuels.

Ken Cook, President & Co-Founder, EWG (01:12:33):

Here's a question from Jerry. Forgive me, Jerry, if I get your last name wrong, Jerry Wink or Winick. Shouldn't we be focusing on parking lot commercial and residential rooftop solar in places like Southern California rather than utility scale solar projects that impact our wildlands and raise biodiversity concerns? Great question.

Mark Z. Jacobson PhD, Professor, Stanford (01:13:03):

Well, I think we need both. Based on our plans for states and countries, there's simply not enough rooftops to power everything. Definitely, more parking lots would be great. France in fact is now going to put 10 gigawatts of solar on parking lots in France alone. We should be doing that as much as possible on roofs. But we also need utility solar because we just need so much energy for all energy sectors. In fact, when we transition, we're going to go down 56% of our energy demand, but all the remaining demand will be electricity. It'll be effectively a little more than doubling or around doubling our electricity demand compared with today. We'd need even more electricity sources than you would if you weren't electrifying all other energy sectors. So both rooftop and utility scale are important.

Ken Cook, President & Co-Founder, EWG (01:14:00):

Here's a question from, John Addison. Dr. Jacobson, I have read *No Miracles Needed* and see it as a great resource for journalists, but critics dismiss your work as flawed. What are their key objections and how do you answer them? I know you've responded to this question many times before, but since it's in the chat, I thought I'd throw it at you.

Mark Z. Jacobson PhD, Professor, Stanford (01:14:19):

Yeah. The funny thing is that most of the critics are people in the nuclear industry or the fossil fuel industry, or they're supporters of that, or they're supporters of natural gas. You know, whenever you propose something that does not include a certain energy technology, you get criticized. One of the main criticisms we had was from a paper from 2015 where we assumed we would add hydropower turbines to existing hydropower dams to increase the peak discharge rate of hydropower without actually increasing the annual water consumption from the hydropower. And I thought that was a great idea. In fact, it's called upgrading a dam. I mean, you basically up upgrade the dam by allowing greater peak discharge to meet peaks and demand. Because hydro is very flexible. That was criticized by people who supported nuclear power. For example,

(01:15:05):

one of the people who supported it, they said, 'well, that's just not feasible to increase the peak discharge rate that much'. But they did think it was feasible to convert the world to a hundred percent nuclear power, because that's what they wrote a paper—<laugh> One of the authors wrote this paper on converting the world to a hundred percent nuclear power requiring like 15,000 nuclear reactors. And they're only 400 today. So it's like people who had a motivation to criticize and then they don't even realize that, these are like, or that particular paper, that was one idea. That's one way to do it. It's not the only way to do it. May not be practical, but it was technically fine. I mean it's something that would work. It all depends on the cost.

(01:15:49):

Anyway, since then we've had other plans that do not include that and we still find that we can match power demand. I think that was our biggest criticism. A lot of people just love going back and talking about that criticism ignoring the fact that we've made like at least 10 papers since then. It's not only our group that's found that we can do a hundred percent renewables in many different ways, but there are like 20 different groups worldwide. In fact, there was a review paper that looked at over 700 papers on 100% renewables that have been published in the peer review literature and more and more every year. So there are only two dozen groups and hundreds to thousands of researchers, and as I've mentioned, over 700 papers on 100% renewables. So I think that the criticisms are getting weaker and weaker as we go along.

Ken Cook, President & Co-Founder, EWG (01:16:43):

I agree. You even have a section in the book reviewing those papers that review <laugh> this issue. So even there, I think it is a great guide for people who want to go deeper. First of all, I love that you approach this as an engineer as opposed to necessarily an environmentalist. Obviously you're motivated by deep environmental commitments, but you're basically asking, how do we solve the problem? As opposed to what's the politically correct solution or what's the solution that'll cause less disruption to the current order of things? You're just taking a straightforward look at it as an engineer. I know your team at Stanford is imbued with that same ethic. I wish we had more engineers like you, Mark.

Mark Z. Jacobson PhD, Professor, Stanford (01:17:33):

Thank you. That's very kind. Appreciate it.

Ken Cook, President & Co-Founder, EWG (01:17:37):

Do we have time for any more or are we about to run out? Bart?

Bart Ziegler PhD, President, SLF (01:17:46):

The way you framed the importance of Mark's work at Stanford is just phenomenal. I'm in the coattails of trying to keep up with each of you. Just really quickly. Someone said it's Paul Gunther is discouraged by Cop 27, dominated by the industry and the lobbyists. You've already touched on what sort of productive way we can march forward. Nancy Van talks about the false arguments against wind such as whales and birds dying. I say buy five copies of the book so she can share it with her friends. And Linda Sealy from Mother's for Peace, says 'I don't feel like we have enough time for the transition with sea level rise'. I guess I'll leave it with you two, to decide what's our best approach moving forward.

Mark Z. Jacobson PhD, Professor, Stanford (01:18:38):

I want to encourage people to stay positive. The good news is we do have the technical and economic ability to solve these problems. Air pollution, climate change, and energy and security. It really takes collective willpower by all of us. I think if we stay positive, we focus. The other thing is to focus on what works. Keeping our old tennis analogy: keep our eye on the ball. Don't get distracted by these fossil fuel ideas of carbon capture, direct air capture, blue hydrogen. Those are just promoted by the fossil fuel industry. They'll get distracted by small modular nuclear reactors or by geoengineering. If it doesn't sound like it's good, then it's probably not good. We need to focus on clean, renewable electricity, heat, cold, and hydrogen storage.

(01:19:30):

Hydrogen should only be used for certain purposes and only it should be green hydrogen. We need electric appliances and machines like electric vehicles, electric heat pumps, electric conduction cooktops in your own home. Weatherize your home, that's the most efficient. Energy efficiency, I didn't really mention that too much. Just reducing energy loss from your home by just sealing cracks, doors, and windows, putting insulation around water pipes, putting even insulation in your garage or in your home if you can do that. Or new insulation on your roof or under the floor and replacing your gas water heater with an electric heat pump water heater, get a heat pump dryer, heat pump air heater and air conditioner, electric induction cooktop. Then also obviously promote or try to educate others around you about what you think is good. Because this is really an information problem. Trying to reach lots of people about what's possible. Most people are just not comfortable that there is a solution. So trying to be encouraging to other people is helpful as well.

Ken Cook, President & Co-Founder, EWG (01:20:39):

Well, I think that's great version and we're in a position now where we're looking forward to the creative side of the environmental future where we can solve these problems. We certainly have to keep opposing the bad stuff. That was the beginning of our movement, saying no to crazy, stupid things, that we're polluting and damaging land and wildlife and Mother Earth just generally. But now I think we're in an era where the creativity to bring about positive change that can happen where you're a little less concerned about regulation if you have a solution that completely changes the nature of the enterprise. We're going to be able to clean things up by doing the right thing instead of spending all our time and efforts stopping the wrong thing.

(01:21:32):

That's very empowering. I think for a new generation of environmentalists to come along and pick up that mantle, think about it like smart engineers: mindful and aware of these possibilities as comes through in your book and all of your work. Mark, I think that's the most exciting thing that's come along in a period where some of our environmental laws and regulations and the old ways of doing things, they just don't work anymore like they used to. I was around when we were passing environmental laws every other year. That was a great period and we got a lot done. We still need to keep pressure in Washington and policy makers and polluting industries and all the rest, but we're playing offense now. These new technologies, these new ways of thinking, these new solution sets, I just think it's very exciting.

(01:22:26):

It scares the hell out of the powers that be, not because they're going get regulated out of existence, but because we won't need them. <laugh> We don't need your coal-fired power plant. We don't need your pipelines and all the rest and your book charts the course. Thank you again so much. Bart and the Samuel Lawrence Foundation, thank you for sponsoring this session and thank everyone for joining. I'm sorry we didn't get to all the questions. A lot of them I noticed you answered in your remarks and they're certainly answered in the book, so buy the book. And one more time the name of this book is *No Miracles Needed: How Today's Technology Can Save Our Climate and Clean Our Air*. And there it is. All right.

Ken Cook, President & Co-Founder, EWG (01:23:10):

Thank you all for joining.

Mark Z. Jacobson PhD, Professor, Stanford (01:23:12):

Thanks Bart. Thanks Ken.

Ken Cook, President & Co-Founder, EWG (01:23:13):

Have a great weekend.

Bart Ziegler PhD, President, SLF (01:23:15):

Ken and Mark. Thank you very much.

Mark Z. Jacobson PhD, Professor, Stanford (01:23:17):
Take care.

Ken Cook, President & Co-Founder, EWG (01:23:20):
Thanks folks.

February 3rd, 2023 – Lyman

Dr. Peter Andersen: 01:01:01 You got it. Well, uh, welcome. I'm Dr. Peter Anderson with Sierra Club and the Coalition for Nuclear Safety. And, uh, we're excited that you've joined us for this webinar on, on nuclear safety and particularly on nuclear waste and a special focus on Sanofi. We have with us today. A fabulous guest, uh, uh, Edwin Lyman. He is a senior scientist, uh, in the Global Security Program of the Union of Concerned Scientists. He's an expert on nuclear safety and, uh, and nuclear disasters. Uh, I've recently perused his book, uh, on the Fukushima disaster, which has been, of course, a huge global problem. And in a couple minutes, uh, he will be joining us. I'm gonna ask him to make a little opening statement about nuclear safety and nuclear waste in general. Then I'll ask him a few questions. Following that, we'll open it up for general dialogue, uh, questions, uh, from all of you attendees. So, Dr. Lyman, are you with us? Hey, my pleasure. Peter Anderson here. Uh, let's begin today and make sure you're unmuted. Are you unmuted?

Dr. Peter Andersen: 01:02:21: […]it's our pleasure to welcome you and, uh, uh, why don't you just begin with a brief opening statement about the hazards of nuclear power with a particular focus on nuclear waste and maybe even a more particular focus on the issues here on the California coast at Santare Diablo Canyon.

Dr. Peter Andersen: 01:02:46 Go it. For those of you that joined us, the Coalition for Nuclear Safety has invited Dr. Lyman to join us. I'm

Dr. Peter Andersen: 01:03:35 The advantage of Zoom calls is that we can all meet from remote locations. The disadvantage is they inevitably have a technological glitch or too. So hopefully, uh, we'll get this, uh, PowerPoint up and running momentarily.

Dr. Edwin Lyman:

01:04:17 All right. So I was asked today to talk about an issue that I've been, uh, concerned about for quite some time, and that's the potential that dry cast storage of nuclear fuel can be sabotaged. Um, and I've been following this, you know, for actually a few decades, uh, the history of this, and there are some recent developments at the Nuclear Regulatory Commission, which I think people should be aware of. So, um, but I have, I have several slides here. I dunno if you want me to help along, you want me to talk, but, um, go ahead. Yeah. So the, the bottom line is that when a nuclear power plant shuts down, uh, the security requirements that are in place to protect both the reactor and the spent fuel, uh, are greatly reduced. And fact, most of the requirements for security, the most rigorous requirements have to do with protecting the reactor itself or the spin fuel pool against attack, because those are the, uh, highest value targets.

01:05:29 But once the reactor shuts down and all the spin fuels been transferred to the pool, for instance, uh, what's happened at, at songs, the requirements for security for that remaining facility that is the isse or the dry cast storage facility, uh, those requirements are much less, uh, intensive. Uh, in fact, uh, while for an operating reactor, the NRC requires that licensees develop what's called a design basis threat. That is a postulated, uh, uh, adversary with certain characteristics, and they have to have a armed response force to interdict and neutralize that threat. For the isc. The current requirement says, um, uh, that the, um, role of security is really just to assess and communicate. That is they need to have, uh, be able to detect intrusion, and they need to be able to pick up the phone call local law enforcement. And there's, of course, inherent delay in that. So the question is, is that good enough for the kinds of threats we're talking about?

01:06:42 And, um, the regulations were really based on the idea that it's hard to sabotage a, uh, dry cask. Uh, you don't have, um, e each cask has a much smaller fraction of, of fuel than the reactor core, the spin fuel pool does. And there's no, uh, there's no real driving force, uh, for rele for severe damage to that spin fuel and for release. Um, so historically, the kind of anal, the kind of attack that's been postulated, uh, for attacking dry ca is to use a, a shaped charge, which is an explosive, um, that is designed to penetrate, uh, a thick barrier, for instance, reinforced concrete or, or steel. But the main point of a shaped charge is actually just to penetrate. It's not to actually, uh, do, uh, uh, severely damage the what's inside. Uh, these are anti-tank weapons. And the, uh, uh, once the uh, tank is penetrated, then there's a high probability that the fuel itself will ignite.

01:07:52 But in a spent fuel cask, you don't have that kind of source, uh, for a potential, uh, or under most circumstances, you don't have that kind of source. So the industry and the NRC and, and Department of Energy all believe that if you just use a shaped charge, uh, you're gonna get a little hole and it's going to just damage a little bit of fuel, and only a tiny amount's gonna get out. So you don't have to worry that much about this. But after the nine 11 attacks, the NRC staff started looking at other ways other than, you know, just a, a shaped charge that you could attack a cask. And they found, um, some troubling, uh, resolved. And this is a quote from, uh, NRC document back in, uh, 2007, uh, that points out that the evaluations that they did of certain specific vendors tasks, uh, did find that there were ways that you could do worse.

01:08:55 Uh, you could sabotage, uh, a spent fuel cask in a way that would lead to a larger release than had been previously assumed. And as a result, the NRC staff at that time believed there needed to be new security rules to address these greater threats. Um, and, um, they, although they pointed out that they didn't know fully what the consequences would be of these kinds of attacks, in other words, how much radiation would be released, uh, what type, you know, what would its form be, how far it would go, um, they, um, did believe that there was the potential that it could exceed the radiation dose limits that were, uh, put in place, uh, for these agencies in the event of a security atta, uh, event. And that, uh, regulatory, uh, standard is that if one of these is attacked, someone at the site boundary should not get a dose greater than five rem.

01:09:55 Um, so the NRC death back into and said, we could do so if, what if you have a situation where you could actually exceed the regulatory requirement with one of these advanced terrorist attacks, the NRC said, well, we should have a rule where there's some systematic way of evaluating that risk, and then adding additional features to reduce the threat. As you could add additional barriers, anyone who's driven by, you know, or, uh, San Nore knows that these casks are out in the open air. You're not required to be in a building. There's no, uh, uh, kind of additional physical protection or structural protection, other, the cast themselves. Uh, maybe you need more, or maybe you need to have security officers who are capable of actually preventing access to the casks. Because if, let's say intruders were able to physically access the area where the casts are, um, and they had a method of, uh, effectively sabotaging one cask, well, they could do that to multiple casks in, in a relatively short period of time, depending on their resources.

01:11:01 So maybe you shouldn't let them get near the cast at all. And, uh, another corollary is, well, maybe you should have a boundary, um, which is further away, so that if there were an event, you could tell the public, um, you know, the public would be restricted to, uh, an area further away where the doses would be smaller. Um, and NRC only recently, um, and, and a document pointed out that a potential release from a hypothetical terrorist attack will be immediate. That means, uh, you're not going to have a long delay, uh, between the attack and the, and the release. Uh, but paradoxically, uh, at songs, um, you know, Edison, um, has claimed that it has, despite what the NRC requirements say that they're doing, uh, their own thing, uh, and even if it's not required. So, uh, it has a vehicle barrier system to prevent, uh, truck bomb from getting too close to the f c.

01:12:05 Uh, it says its security is going to maintain that capability to interdict the neutralized threats, even though the NRC doesn't require it. Um, but also, uh, because of, um, other factors and considerations, it wants to reduce the distance, uh, to the controlled area boundary from, uh, the currently required 100 meters now to 38 meters on the ocean side. That would be, uh, contradicting the staff's recommendation that you may need to actually increase that, that boundary. Um, and in any event, uh, those voluntary measures that Edison has put into place are not inspectable or enforceable by the nrc. So the public doesn't have any real means of, of assessing whether, uh, it's a good enough. Um, and this just an indication of how bad, uh, the doses could be because, um, even a single spent fuel cask might have 10 tons, or let's say 20 <inaudible> assemblies was spent fuel.

01:13:11 This is a, a study that was done by the Department of Energy, uh, and showed that even a single, uh, spin fuel assembly that is one 20th of what might be of large tasks at at songs, uh, if that released, uh, different fractions of radioactivity, these are the doses that you might expect, uh, at the site boundary. And so you see that if you're getting up toward, um, 0.1%, uh, or even 0.01% that these, uh, areas that are accessible to the public, that is the blue arrows, uh, is route the distance away from route five. Uh, so you see that at, uh, 0.01%, uh, release, uh, you could actually challenge that regulatory boundary, which is this, uh, black dotted line, horizontal line. And what if you had enhanced releases of 0.1% or more, you would have pretty high at the controlled area boundary or, um, or, uh, refi.

01:14:16 So these, these are pretty significant results, and you would think that, well, maybe they need to do more, uh, to protect the public from this kind of an attack. Uh, and so, but unfortunately, the N R t, uh, in what they have themselves characterize as a complex rulemaking history, uh, have gone in circles on this issue. Uh, so even though the staff recommended they need to do something, back in 2007, uh, the N R C didn't really do anything except some additional studies. And finally, in 2015 said, well, you know, this isn't urgent, so let's think about it for another five years. But then before that five years was even up, the NRC decided, well, maybe we don't really need to do anything at all. Maybe the measures that we required after September 11th, which are not public and are not part of the rules, were good enough.

01:15:11 Uh, and, um, in 2019, the staff finally said, well, maybe we should just put an end to this. We don't need to do anything more, uh, to protect ites. Uh, but in 2021, the commissioners said, not so fast. Um, we want you to give us recommendations and reconsider the options, including a rulemaking. Uh, so that's, um, unfortunately in November, 2022, the staff came back to the NRC commissioners and said, all right, we've thought about it, uh, but we've decided we still don't need to do anything. We don't need this rule. Um, we looked, we had San Diego National Laboratories do studies of how data would be if these casts were sabotaged with these enhanced methods. Um, but we don't think their results were, we think they're too conservative, and they didn't, they're not realistic. Uh, so that's not the basis for doing anything. They didn't say that.

01:16:06 Um, uh, so they just said that study wasn't the basis for doing something. They didn't say, uh, there's no basis for doing anything, but they conclude in any way. We don't think there's a problem. And that's where things are now. The NRC commissioners now need to vote on this proposal. And I have to say, from my discussions, um, at the nrc, I'm not hopeful that the commissioner is gonna vote to, uh, say we need to go forward with this rule, and therefore it's gonna leave things, uh, in this, um, uncertain state with pot, uh, potentially higher vulnerabilities, uh, with regard to both San no phrase fc, as well as all the other ones around the country at, at decommissioning plans. So, I'll stop there and be happy to, uh, open up the discussion. Thank you.

Dr. Peter Andersen: 01:16:51 Yeah. Let me, uh, let me begin, if I may, with a couple of questions. Uh, the first one is what, you know, the prevailing winds in, uh, in, uh, north County San Diego are west, northwest, southwest. Uh, if there was a major breach of a, of, of one or more casks, uh, how much, how much would wind carry harmful radiation into communities in North San Diego County or South Orange County?

Dr. Edwin Lyman: 01:17:22 Well, again, you know, it really depends on the meteorological conditions. At the time. I did show that graph, um, uh, which is only for one modeling, uh, one weather condition. Uh, and so it really depends on, on the winds and the stability and all the other factors that go into how aerosols are dispersed. Um, but, um, I would say, you know, you could have, um, you know, and again, it, it depends on the magnitude of the release and how credible these different attack options are and how many casts were sabotaged, how much spent fuel was, um, damaged in each one. But it, you know, it is plausible. You would have, uh, detectable contamination as far as, um, many, uh, tens of miles away. Um, and, but, uh, you know, it also depends on how big the particles are. If they're, you know, if they're relatively large, uh, aerosol, uh, they may not disperse that far, they'll fall out closer to the, to the release site.

01:18:30 And a lot of that is not known, that's the problem. It's, uh, very difficult to do the kind of testing that we give answers to some of these questions. For instance, what do those aerosols, uh, look like if you had this kind of an attack? Um, you know, there's very limited data with, well, there's no real, no data with real spent fuel. There's data with stimulants for some of the older types of attacks, even that's a hard type of thing to do. Uh, there was a proposal back maybe, uh, 15 years ago now, uh, to do testing at

Sandia National Laboratories with actual spent fuel sabotaging cast that would, uh, these are very dangerous experiments, obviously, and the Department of Energy ended up not funding it. Uh, so, you know, we don't know, uh, really, uh, but, um,

Dr. Peter Andersen: 01:19:23 Yeah, it sounds like, uh, some of the procedures for ensuring the safety of these tasks involve things like direct access or, uh, truck bomb blowing up near it. Uh, but there's concerns about an aerial attack or a missile attack from, uh, the freeway or a missile attack from the Pacific. Uh, could those be highly disruptive and potentially rupture, uh, a number of casts that are sitting there on the beach?

Dr. Edwin Lyman: 01:19:55 Well, in my view, you know, a single explosive charge is not necessarily going to challenge, um, <affirmative>, um, a, uh, a dry cast depending on, you know, the, the particular caste design. Um, uh, it, it takes more, you know, it would take more than a single explosive, uh, because they are thick walled casts. So you do need some way of both penetrating the cast and also, uh, causing some disturbance to the spin fuel that would somehow get it to, uh, you know, potentially even, uh, catch fire.

Dr. Peter Andersen: 01:20:40 Sure. Now,

Dr. Edwin Lyman: 01:20:42 In

Dr. Peter Andersen: 01:20:42 The, in the war in Ukraine, we've seen the use of, uh, bunker buster, uh, missile attacks on it. Uh, are you, uh, what, what's your assessment about the use of such a weapon in the hand of a terrorist, uh, being launched at it that would in fact be able to crack concrete and penetrate the device?

Dr. Edwin Lyman: 01:21:04 Yeah. Well, some of these, you know, sort of advanced adversary attack modes, um, might involve that kind of two stage. So, right. So you need to not only drill a hole, but you need to get some sort of, uh, explosive or some, uh, some way of, um, damaging the contents inside as well, and potentially causing these over pressures. That's all part of the, um, that analysis of these additional attack modes. And then it's a question of how plausible it is, uh, for, let's say, terrorists to obtain those kinds of weapons. Because another important thing to consider is the N R C does not require nuclear facilities to be protected against enemy of the state attacks. Uh, so anything that would be within the capability of a nation, but not in a plausibly within the capability of a subnational terrorist group, is something that the utilities or the plan owners do not have to worry about. That's supposed to be the responsibility of the, of the federal government, military, and where you draw that line can be tricky because, you know, you also have, uh, terrorist groups that have had state support and might be receiving, you know, both financial and also substantive, um, uh, resources from states. Um, but that kind of thing is a middle ground, uh, which is just not considered Sure, uh, right down. Yeah.

Dr. Peter Andersen: 01:22:32 I'm gonna pose one final question to you and then let's open it up for more general, uh, discussion, if we may. Um, that is, uh, if this were to be moved, uh, off of its present location on the beach at Santa Nore, uh, deeper within Camp Pendleton, or to an alternative site farther away in the state of California, uh, would that enhance the security of this particular site?

Dr. Edwin Lyman: 01:23:02 Well, it would certainly enhance the security of the site, you know, or the, the, if the waste were not there. But, you know, my my own view about the kind of general problem, you know, is that you have, you know, many, uh, spent fuel storage sites around the country Sure. And they all have their own vulnerabilities. Some are closer to populated areas, some are in more protected areas, some are in less protected. Uh, e everyone's in the, in the same boat more or less. And we're not gonna solve the problem just by kind of rearranging the deck chairs and the Titanic. You know, I mean, um, you know, it, the sad thing about this issue and, uh, spent fuel disposal or management disposal is how it does tend to pit, uh, communities, uh, against each other, right? Everyone wants it out of their backyard, but then someone else is gonna get in their backyard.

01:23:55 So you have to, um, but I do think that there are, you know, certain outlier, uh, you know, um, examples where it may make sense to relocate spin fuel, but you do have to worry about the potential for an accident, uh, during that process, not only, you know, uh, uh, moving and, and transporting and, and additionally handling those casts. So, you know, trying to figure all that out is difficult. And, you know, I sympathize with the communities that are stuck with this stuff. Uh, but we do need a national, a solution that doesn't, uh, just heap that risk on, uh, let's say communities that are less well resourced. Sure. And, uh, able to launch opposition to that kind of a project.

Dr. Peter Andersen: 01:24:44 Okay. Dr. Ziegler, uh, Bart, uh, let's open it up for general discussion. Uh,

SLF: 01:24:50 And Dr. Anderson, Dr. Lyman, thank you so much. We do have quite a few questions coming in, please. So I'm gonna start with the first one.

Dr. Peter Andersen: 01:24:58 Go for

SLF: 01:24:58 It. And this one is from Sarah. Does the fact that the canisters at songs and most other plants in the US are thin walled as opposed to thick walled cast used in most other countries, figure it all into the discussions of the vulnerabil vulnerability to sabotage?

Dr. Edwin Lyman: 01:25:20 You know, again, the, the problem is that the vulnerability, you know, it depends on two things. One is the nature of the cas itself, and the other is the nature of the attack. And I would say that, you know, just saying thin walder not as good as thick walled, uh, isn't, you know, you can't make a general statement that that's true because it really does depend on, on the attack mode. It could be that there's little difference with regard to some of the attacks that are possible. And, you know, it's really the seals and the, and the lid. In some cases, it could be the most vulnerable rather than, um, uh, than trying to get through the wall. So I'd say that generally you can't make that kind of inclusion, but I can't say that, you know, it is very specific to various, uh, designs as well as to the attack modes you're considering. And that without having that kind of information, which, um, the n r c rightly, uh, classifies, um, it's very hard to make, uh, that kind of a conclusion.

Dr. Bart Ziegler: 01:26:27 Um, and Dr. And Dr. Levi interrupt for a second, ahead second and say, um, pill loho. We have a, we have a question from Gordon Edwards. Um, he says, would an incendiary penetrated device release radioactive cesium vapors, would this be more dangerous than particulates?

Dr. Edwin Lyman: 01:26:46 Well, c um, metal has this unpleasant property that, um, it has a relatively low, uh, vaporization point. And so when, uh, for instance, in an accident where spent fuel is heated up above, you know, uh, around 600 degrees Celsius, that cesium, uh, if it's a metallic, uh, form, does vaporize and it'll condense rather rapidly, but, you know, condensed to small particles. So that depend, that could lead to why, you know, a type of aerosol that could be dis dispersed more widely. That's certainly an issue in a consideration. Whether, um, you know, that would actually be formed depends again, on, on all these details, which, uh, you know, the analyses are classified, but also the data available to validate those analyses is often not, not, um, available even to the analysts. So it's really hard to say.

Dr. Bart Ziegler: 01:27:50 And, and another question, uh, from Gordon Edwards, uh, is, is, thank you, ed. What's the, what's the maximum eternal temperature in one of the, these, uh, dry casks? I, is there some residual water inside the cask when it is dry sealed, despite the drying procedures? Would this not result in some steam pressure inside?

Dr. Edwin Lyman: 01:28:15 No. Obviously, the, um, you know, the loading requirements are to make sure that it's dry. Um, it, it's hard to imagine that you would get significant steam pressure. I haven't thought about it, but from the amount of residual water you could have, um, that would challenge, uh, the structural integrity of the cask. You know, the, the real, you know, the real issue is whether the, you know, the biggest vulnerability of the caste structures, again, are the seals around, around the lid. And that's really what fails first. If you have, um, uh, things like, you know, accident scenarios like an engulfing fire, uh, is that it's the seals that fail rather than the structure of the cast. Um, uh, so, you know, again, all, all these factors, I, I, I can't get too specific. Um, but again, there are just a number of different factors that have to be considered in this, in this type of analysis. And like I said, it's just the data, um, not, not only is not available to the public, but it's often not available to the analysts.

Dr. Bart Ziegler: 01:29:28 There's, and there's a question here from Roger Johnson. Um, if we move, uh, way beyond intruders and sabotage, please address high explosives and airplane crash, maybe rockets or mortars from 23 parking lot miles away, right? Maybe missiles 1200 pounds warheads launched from cargo ships. Um, what would happen if the canisters were blown up, how much radiation could be spread?

Dr. Edwin Lyman: 01:29:57 Yeah. I do think, you know, my very limited understanding, I do think it would take more than a typical ordinance, single ordinance attack to, to damage spent fuel. There are, there are kind of smarter ways to do it, but they would require physical access. Uh, um, you know, a mortar, you know, explosives have, have a limited ability to penetrate reinforced concrete. Um, that's why shaped charges were designed because they have that property of focusing the explosive in a way to get that, uh, to get it, uh, penetration. But the kind of, um, bulk explosives that, uh, you know, that would be targeted at larger structures. I, I just, I don't think those are the scenarios that I worry about the most.

Dr. Bart Ziegler: 01:31:01 Peter, what do you think? Um, here's another question from, uh, Nancy Vann. What, what do you mean by thick casks? I guess she's talking about thin canisters, which is what we have here at Senate <inaudible> and thick casks, which are what Donna Gilmore talks about all the time, as

Dr. Edwin Lyman: 01:31:21 You know. Yeah. Again, I don't, you know, whether the wall of the canister, they also have overtax and you have to consider both. So, again, I don't, um, I don't think that you can make blanket statements. Um, you know, but again, it's very attack specific, but I, I don't think, you know, my personal view is that there are other design factors that are more important than the thickness of the canister.

Dr. Bart Ziegler: 01:31:52 Uh, ACE Hoffman has a question. Someone stole a tank in San Diego some years ago, a US pilot went crazy and flew his fully armed jet into the mountains during a training flight. Do bullets Oh, oh depleted uranium bullets can easily go through many inches of steel and concrete, then burn inside the target. None of this is classified, nor are dozens of other weapons that can penetrate and destroy dry casks. How would you like to answer that big one?

Dr. Edwin Lyman: 01:32:28 I think I already did. Um, you need something more, you know, if you don't have, you don't have a fuel source inside these casks, um, that it's going to ignite with, um, you know, depleted uranium shrapnel still needs to be oxidized. You know, it's, um, you know, I think the point of my talk rather than is really that we should focus on what the required protection is and what it should be. Yeah. And I think the big issue here is that there is this gap, uh, between what the NRC staff themselves had identified as possibly plausible attack scenarios and what the current regulatory requirements say. And that gap itself is enough to be a concern. You know, I'm, I'm not gonna worry as much about, you know, kind of speculative, you know, missile attacks from foreign powers, uh, as the potential to use common or relatively common tools or techniques, uh, that, that are more readily available, but could be leveraged.

01:33:40 I think that's where our focus really needs to be. Or they're not, not not looking at the more exotic, uh, weapon systems, but also kind of garden variety stuff, uh, that might be weaponized in this context. And I can't say anymore because, um, um, I actually did have a security clearance, and I did, I was, uh, saw, uh, some of the data associated with this issue. Uh, so, uh, I don't wanna get any really specific and I can't. Um, but, uh, you know, I, I would just point to the fact that the NRC staff themselves identified, uh, this, uh, also, I think I mentioned this on the slide, that, um, uh, they did this proof of concept testing, and this is public. They went out in 2013 to white stand's missile range, and they tried to blow up mock spent fuel casts in various different ways. They took movies of them, and the conclusion was, well, some of the ideas they had weren't that effective, but others were. And, uh, so there's a gap. There are things that could be pretty bad, uh, but the NRC is not on a tr a trajectory to doing anything about him. That's, that's, uh, the, I think, the most urgent concern right now. Looks like we have another question,

SLF: 01:35:03 Dr. Lyman and Dr. Anderson. Um, Dr. Lyman, from just looking at all the questions, um, as the host, I would say I agree the biggest concern is the gap, but I guess the question would be what can we do as participants in this issue to help make that gap change?

Dr. Edwin Lyman: 01:35:27 Well, um, you know, there's always letter writing, and right now it's up to the commissioners, uh, the NRC commissioners to vote on what to do. They haven't voted yet, as far as I know. So if there were a public campaign telling them that they should not, you know, punt on this issue, uh, that they at least should go to the next, uh, stage, uh, and not rely on, you know, what seems to be a single sand national laboratory study if the NRC staff doesn't trust, but to, uh, further evaluation, uh, that, that, that that would be warranted. And also, you know, uh, uh, Congressman Levin, you know, is, is interested in this issue and, uh, you know, hopefully he may weigh in. Um, uh, but, you know, that's, you know, the, the ball is in the, uh, NRC commissioner's court right now. And, uh, I, I don't get a whole whole lot of sense that, um, they're that concerned about, or at least, um, the majority of the commissioners, um, seem to agree with the staff that they don't need to do anything. And I just, just looking at the whole history of this issue, I don't, I just don't see, uh, why that would be true.

SLF: 01:36:45 Can the states actively be more in a campaign status versus just a nationwide can The states rally together to do some petitioning?

Dr. Edwin Lyman: 01:36:58 Certainly, you know, the state governments are entities that have, you know, rights and, and, um, can weigh in at the NRC as, as any other, you know, um, interested party can. Um, and this, you know, this is an issue for any, any state that is hosting this seize, uh, especially those at decommissioning reactors. So I would hope, um, you know, uh, that more public attention on this would get the NRC to do the right decision, make the right decision.

SLF: 01:37:32 Thank you.

Dr. Bart Ziegler: 01:37:33 Speaking of, um, decommissioning, I, there's a question here from Linda Sealy who's with Mothers for Peace up at Diablo Canyon, and they're ab hopefully about two, according to the NRCS recent decision about to work on decommissioning there, she says, what are the other design factors that are most important other than the thickness of the casks or canisters?

Dr. Edwin Lyman: 01:38:00 Well, like, like I said, it's the, you know, uh, typically the, the greatest vulnerability are around the, the lids and the seals, because, um, and you know, mo most casks use a kind of vetoer seal, which loses its ceiling ability at, at relatively low temperatures. So when you do fire analysis for these casts, you have to show, you know, the, you know, we probably all know that the fire standards are relatively lax for waste packages, that it's only in half hour fire in debris Celsius. But the goal is to show that that won't cause the seals to fail. Uh, they're kinda the most vulnerable part. Um, and you know, it, it's not just the, the thickness of the material, but it's also the structural strength and the other properties it has, uh, which also go into, come into play. And again, I just, I just can't say generally, uh, that one is better than the other. Like I said before, uh, it's just a very complex type of analysis.

Dr. Bart Ziegler: 01:39:09 Wow. There are, Peter, should I just read some of these questions you think? Feel free. Okay. Cuz Bill Weigel says, do do you think, um, do you think it's a good idea to store this high level nuclear waste on a military installation, which makes it a legitimate target under the laws of war? Have we not just prepositioned a weapon of mass destruction for our enemies to use against us in time of war? Wow, that's sort of <laugh>.

Dr. Edwin Lyman: 01:39:41 You know, I, I try not, um, I don't know if I have a real response to that. Um, you know, obviously a, again, you know, the, the problem is that protecting against enemies of the state is out of the, you know, the NRC has said it's out of its purview. And, um, that in itself is a, is an issue not, not just for facilities like these, but for any critical infrastructure facility where, uh, that is potentially vulnerable to a military attack. So, um, so I think that's a larger issue, uh, that has to be addressed.

Dr. Bart Ziegler: 01:40:25 Okay. Uh, Paul Gunther says, Dr. Lineman, do you support on force drills at is Fases? Why has the NRC not proceeded with the rulemaking to initiate force on force exercises?

Dr. Edwin Lyman: 01:40:41 I think that would be, that should be part of the considerations if there were rulemaking going forward. Uh, and just to explain, uh, for operating reactors, uh, with that security force that has to ha mind an armed response and show they can interdict and neutralize this, uh, design basis threat, the NRC requires, um, uh, that not only the plan owners themselves do drills once a year, uh, actual full force and force drills to demonstrate that capability with their security force, but also the NRC inspects every three years running its own, um, uh, inspection with its own scenarios and, and its own, or well, using an industry-wide, um, composite adversary force as a surrogate, but ostensibly under NRC direction, uh, to test the security of these facilities. But all that goes away, uh, when the reactor shuts down, you just have the <inaudible>. But if, um, you have, you know, if there are potential scenarios where adversaries could get to the casks in a relatively short period of time, and, you know, uh, like at songs, um, you know, the, that security fence and the controlled area boundaries is pretty small.

01:42:06 And, you know, they, um, uh, if they could get, you need to know how, what the timelines are for them to get to the, where the waste is for them to apply these advanced techniques. How many tasks could they do at once, um, and how long would that, and what are the measures to prevent them from sabotaging those tasks? And, and you need to test that because if the current strategy is called 9 1 1 and get the local law enforcement to show up, uh, if this, uh, you know, if this unfolds too fast, that's not gonna happen. So, uh, full-blown, you know, exercises involving all the entities who are supposed to respond, showing they can actually do what they're supposed to do, it would be critical. So, yes, uh, short answer is yes, I do think that should be part of this enhanced, uh, uh, regulatory requirement.

Dr. Bart Ziegler: 01:43:03 That, that's just a great answer because Daniel Hirsch writes, 20 years ago with Lockba, with Dave Lockba, they wrote an article for the Bulletin of Atomic Scientists criticizing NRCS design basis, the threat regulations for operating plants. Of course, at Santare Wheat, we have the waste dump there that is vulnerable, as you explained. It says, given the efforts to extend Diablo's operations, what can you tell us about the adequacy of nrcs current design basis threat requirements, Stan Hirsch, which is what you just sort of answered,

Dr. Edwin Lyman: 01:43:38 Right? And that's a whole, you know, that's a whole other fight because that, you know, um, this is a situation where the design base thread effectively doesn't apply anymore, no matter how, you know, what it is. Uh, but if you look at the, uh, the design basis threat for operating reactors that are serious questions about whether that is adequate. Um, and, um, and it's not just the, the threat itself, but how it's applied, um, and that, that's, that's really a subject for all of the talk. But the, the short answer again, is no, I don't think, uh, the, the, the changes that were made to the design base threat after nine 11, uh, were sufficient, uh, to really address the postulated threat or the, you know, the threat that we think does exist. Um, and it's not just the what's in the rules, but it's also their, again, their application and their interpretation.

01:44:42 And the whole other thing that I was involved in for a long time was, uh, what are the assumptions, uh, that are made about how these adversaries operate? What, um, what are the kind of rules for understanding the outcome of, let's say, force and force exercises or, um, and the industry was, was, has been pressing for more or less successfully is kind of bounding how the adversaries can even use the tools that they're provide in the design basis. Right? And, um, you know, I can't really say more about that, but it's, it's, it goes well beyond just what's in the regulations. Uh, and, um, uh, a more troubling or development is, again, related, um, is a separate proposal that would reduce the, um, responsibilities of the security force at operating reactors so that, uh, local law enforcement would actually have a more fundamental role, their response in plant security than is currently the case.

01:45:57 This is a very dangerous proposal, and again, a lot of the same, uh, ideas are similar, that you can't count on local law enforcement. They're not under the, uh, control of the licensee. They're not under the control of the nrc. The NRC has no authority to tell them what to do. Um, and unless if you give them more responsibility without ensuring that they can carry out that responsibility in some way, you're abrogating your regulatory authority. And that seems to be what, what the direction is, um, of things is going at the nrc. All, all very troubling.

Dr. Peter Andersen: 01:46:36 And, uh, quick question, local law enforcement, uh, is not only not under the direction nrc, uh, but they're not really prepared, are they for, uh, dealing with, uh, both an attack in the release of radiation? I mean, they don't, they don't have radiation gear that would protect themselves, do they?

Dr. Edwin Lyman: 01:47:01 Well, that, that would depend, you know, some local law enforcement, uh, may have specialized, uh, uh, personnel or some training that, you know, after nine 11, you know, there was more concern about radiological terrorism. Department of Homeland Security, uh, provided some funding. But again, it's not really, uh, you know, part of their normal operations. And it's not clear if that funding, you know, it's really, uh, sporadic. Who knows if it's been sustained, who knows if they're getting that kind of training, uh, that that's all part of the, this problem is that you, you, um, don't know if that response is going to be equipped to cope with this, uh, with the, uh, the potential scenarios. And unless you, um, ensure that they have the resources and the training and you test that they can execute, uh, these, these missions, then you're really just, you're exchanging something for nothing. Right. The, um, the, uh, for better or worse, those security forces at, at the plants as well as the onsite radiation protection and everything else, um, you know, at least there's some regulatory control over them and their qualifications and, and everything else. And none of that, you know, it's just a, a black box, uh, with regard to what local law enforcement can or can't do.

Dr. Peter Andersen: 01:48:27 Thanks.

Dr. Bart Ziegler: 01:48:32 So, um, there could be some background leaks. That's also a concern. You know, we're worried about tsunamis and El Ninos and a whole bunch of fires and just disastrous, um, climate change. Um, but back to a concern that we have here at San Nore is if there's a, a cracked canister and it starts to leak, do you know about the UCSD's, um, essentially invention using, uh, simple detection manners to look at leaks ahead of time, early warning monitoring that's been developed here?

Dr. Edwin Lyman: 01:49:17 Yeah, again, I'm not really, no, not really prepared to talk about that. Um, you know, again, my, my, my deepest concern are those events that could really lead to catastrophic consequences. And, um, and making sure that there's adequate, uh, protection to make sure those events are, are very unlikely and, and can be dealt with. And so that's sort of where, you know, the focus of my concern is those highest consequence events, you know, routine releases or, you know, um, you know, again, it's a big subject and I'm not really prepared to talk about it today, but, uh, what I do know, you know, is that if there's the potential for a, a severe, uh, you know, energetic event that could really damage or even melt spent fuel in the cask, uh, that, that's, by that, that's orders of magnitude worse than what you would expect from, uh, a routine leak.

Dr. Bart Ziegler: 01:50:26 If you were to give us three or four take home points from this discussion, and, and it's just so wonderful that you took their time to, to, to uh, share this, this wisdom with everyone on the call, what would you say is the most I the pressing issues for santare at, at this time? Or any, any, yeah,

Dr. Edwin Lyman: 01:50:49 So, right. So to recap, um, you know, the NRC staff identified that the, um, uh, that the types of attacks that could plausibly occur, um, at a, at an fc, uh, that there are some that could lead potentially to worse radiation releases than what the current regulatory, uh, requirements assume. Uh, the n the NRC for more than 15 years has been kind of batting around the possibility of strengthening requirements. The industry is united and opposing any such increase in requirements, um, and through ups and downs, uh, this issue has stayed alive. But now, um, we're we're at the point where it could be shut down entirely. Um, and my belief is that the available evidence in public is sufficient, uh, to say that there do need to be increased, uh, security requirements for fcs, and the NRC is, uh, on the verge of potentially, uh, not fulfilling that, uh, responsibility.

01:52:04 And that's, that's a problem. And that would mean that, um, communities like those around San Freight are an undue risk of, uh, a large radiological release that not only would pose acute hazards, but also could lead to widespread radiological contamination that would make it difficult, uh, to live in, in some of these close communities. It could ruin, uh, the natural resource of the beautiful coastline. Uh, and, um, that, that, you know, that's a whole other issue is that the, the NRC doesn't even consider that, uh, in, its, in its dose requirements. All it looks at is someone standing at the fence line, you know, controlled area boundary, something happens, how much radiation are they going to get standing there? It doesn't look at what happens afterward. If you have, let's say, season 1 37 dispersed across the landscape, uh, that has a 30 or half life, uh, the NRC refuses to, uh, consider those kind of longer term issues in part as part of their analysis. And that's another gap you could have releases that may not exceed the regulatory limit at the fence line, but would still be a big problem for people within, uh, five or 10 miles on the site.

Dr. Bart Ziegler: 01:53:29 You know, there are 9 million people within 50 miles. It is, it's a nice place to live.

Dr. Edwin Lyman: 01:53:35 I know, <laugh>,

Dr. Bart Ziegler: 01:53:37 Peter, what do you say?

Dr. Peter Andersen: 01:53:40 Well, what, what, what would be the benefits of having a hot cell on site at Nore to deal with any potential disruption of, uh, one of the canisters?

Dr. Edwin Lyman: 01:53:56 Yeah, again, um, slightly side issue, but I do agree that, um, not having that capability at reactor sites, uh, is probably gonna be a problem in the medium to long term. And of course, you know, if, you know, if, if there were an attack, uh, even if it didn't lead to a large offsite release, you're still going to have a mess onsite. Uh, and without, uh, without available capabilities to address, uh, uh, the, the damage that, uh, that could be caused to the fuel in the casp, uh, that cask, you know, let's say there was significant damage to the fuel, but it didn't leak out. Uh, but still, you're not gonna be able to move that cask, you know, uh, the container maybe damaged, um, and you would wanna repack it, uh, and without that hot cell capability, I agree, uh, it's, um, it'll probably in increase the, uh, likelihood that that stuff is gonna stay where it is in its damaged state indefinitely.

Dr. Peter Andersen: 01:55:07 And even, even that small radiological release onsite that does not threaten neighboring communities, that would probably have some impact on interstate five. Would it not

Dr. Edwin Lyman: 01:55:26 Looking at how close, um, the FC is to the interstate as well as those, um, uh, you know, those, that, that diagram I showed you did, did show that how much, you know, the extent to radiation release within that hundred or 200 meters, uh, could be substantial. So, yes.

Dr. Bart Ziegler: 01:55:57 Um,

Dr. Peter Andersen: 01:55:59 Are there additional questions from our guests or panelists?

Dr. Bart Ziegler: 01:56:03 Oh, Michelle Lee says, isn't the fact that this is in the providence of the nrc, which has a conflict of interest, a key reason for concern, more confidence would come from scenarios developed by the military, military intelligence, cybersecurity experts with red team blue team exercises. What, how would you like to

Dr. Edwin Lyman: 01:56:24 Yeah, that, that's actually a very important point because, um, you know, a, after nine 11, the Department of Homeland Security was formed, it's, you know, part of its mission was to, uh, protect domestic infrastructure, but it got involved in turf battles pretty early on with the various agencies, uh, uh, with regard to their, the facilities that they regulate. So my, my reading of the history was that that Department of Homeland Security, I don't think really, um, had enough of its own independent technical expertise to challenge the nrc, the nrc, you know, you know, nuclear issues, nuclear physics, nuclear engineering, you know, just looks so complicated. You know, the NRC can kind of maintain the status within the inter-agency process of, you know, we're, we're the only ones who understand this, and that's intimidating. And I think that they were able to really retain that turf, uh, through intimidating other agencies, uh, with the technical, you know, opacity of so much of what they do.

01:57:36 And I think that's an ongoing problem, um, because other agencies do have equities in, um, how, uh, the NRC regulates these facilities is one example. Um, I was involved in a kind of short-lived effort that the Air Force had initiated, uh, that there was a concern amongst some of the Air Force that an electromagnetic pulse event, um, that would cause widespread grid, uh, failure, uh, could lead to severe, uh, you know, conditions, developing station blackouts and nuclear plants. It would affect, uh, reactors and spin fuel and air force bases that are, uh, near nuclear civilian nuclear power plants. Could be their, uh, activities could be severely compromised by radiation release. Uh, and so the air, you know, some of the Air Force, you know, tried to organize these meetings with the NRC, talk about their concerns, but ultimately, you know, the NRC prevailed with its, you know, technical, uh, it's overbearing technical posture, and, um, nothing happened.

01:58:49 The Air Force backed down, uh, for one reason or another. So, um, uh, I, I do worry that, um, that, you know, the NRC has seen sort of the be all and end all of decision making with regards to civilian nuclear power. I mean, that's, their, their, well, that's what the law says, but they do have their own ways of doing things. They do have, they are compromised, uh, to some extent by, you know, by the conflict of interest, by the regulatory capture. And, um, there is no independent, real independent check on that, you know, you'd think the, um, as far as I know, as far as I can see,

Dr. Bart Ziegler: 01:59:37 I mean, there's, there's an interesting question here if we have, if we have a second from Mace Hoffman, about what do you think about ar gen's haws idea that would include separating the fuel into separate areas with berms, breach canister. Would that be useful? For example, if an airplane strikes or accidental intentional, perhaps one or two casts would be involved in the conflagration with physical damages?

Dr. Edwin Lyman: 01:59:58 Well, right. What I'm, what I'm really talking about is, is Haas or a regulatory, you know, requirement that would, could potentially lead to hostly HOAs like, uh, you know, features if it was shown that the way the current configurations of FCS were, were inadequate, and that could, you know, involve a lot of those hardening aspects that, that the HOAs includes, in fact, part of this decision that the NRC will make, uh, would also involve dismissing a petition. I think it was by, um, was it by C 10. People in the audience probably know that there was a petition a long time ago, uh, to adopt Haas, and that would be, that's really incorporated into this N R C uh, decision if they dismiss the need for new regulation in this area. You're also dismissing the petitioner on host.

Dr. Peter Andersen: 02:00:56 So if we were to do a letter writing campaign, uh, with our members, uh, uh, to the, uh, N R C, uh, what are the top two bullets that should be in those letters requesting them to do?

Dr. Edwin Lyman: 02:01:16 Yeah, I think the, um, the top bullet was, is we, um, were concerned about the inadequacy of current security requirements for fcs. Uh, the NRC has a chance to, uh, have a public process, uh, you know, to the extent possible, um, to, uh, review these concerns. And that, that would be the best way to do that, would be through a, a rulemaking, uh, where, uh, you would have a full regulatory analysis of, of what needs to be done, if you know, or what are the options for closing this gap? And, and security forums.

SLF: 02:02:02 And Dr. Anderson, Dr. Lyman, we are at the one hour mark. Are we open to a few more questions or just wanna

Dr. Bart Ziegler: 02:02:11 Do we have 30 seconds for one last question from Liz Shearer, whose, whose idea for the Coalition for Nuclear Safety, she says, what are the most important issues the community should address at this time for Santa Nore? And I think you've answered that a couple times.

Dr. Edwin Lyman: 02:02:27 Yeah. Again, this, um, I'm really highlighting one, one of the aspects that I think is most risk significant. That's why I focused on it now. You know, the thread of radiological terrorism sabotage is very hard to, to get your arms around, hard to define. Uh, but you know, I'm, I'm a firm believer that you need to, um, assume, uh, you know, the worst and, and prepare for it. And that includes, uh, uh, you know, a, a conservative view of these threats, especially as, um, you know, we'll have to see how the domestic subnational, extremist violent extremist threat evolves, uh, you know, since, uh, you know, the Trump era and, um, in January 6th, uh, and the infiltration of local law enforcement by these extremist groups, as well as another consideration, uh, that threat may be, you know, continue to be ascendant and with the fire power available, uh, to the general US population, you know, which, um, is extreme. Uh, then, you know, I, I do worry that organized, uh, conspiracies, uh, to cause this kind of radiological sabotage where attacking other critical infrastructure may continue to, to strengthen and, um, spent fuel. You know, it's here, it's here for decades. It's here for centuries. Who knows how long, you know, who knows what'll happen over those that period of time? Don't we wanna look forward? Uh, uh, and, and, uh, you know, rather than just lock everything into the way things are now since spent fuel is, is forever. We need to have, be more forward looking.

Dr. Peter Andersen: 02:04:22 Uh, Dr. Lyman, uh, on, on behalf of the Coalition for Nuclear Safety, thanks so much for some objective and enlightening comments. Uh, we, we greatly appreciate your expertise. You've given us some great ideas, uh, for future discussion, for future activities. Uh, Siegler, do you have any final words?

Dr. Bart Ziegler: 02:04:42 Yeah, you guys are volunteers. This is the, this is the generous, this is generous public service. I'm just so grateful to you, Dr. Peter Anderson and Dr. Edwin Lyman. Thank you very much for doing so well in the university and just achieving such, um, skills that you can share with, that you can air with all of us. It's just a pleasure to, uh, unite everyone together to find a solution. Thanks a lot.

Dr. Edwin Lyman: 02:05:09 Thank you. Thanks for having me. I appreciate it. Have a good weekend. Be safe.

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Joe: Thank you for that nice intro and good. Good afternoon, everybody. Good morning. I'm going to talk, hopefully no more than ten, 15 minutes and then I'd really like to open the floor for questions and discussion. My topic is health studies near nuclear plants. And very often when I speak, it's about results. It's about cancer trends and pattern and so on. This one's going to be a little different because I'm going to be framing this in a in a political way and in a in a political framework, because as we all know, the issue of health risk. From nuclear power is very, very much politicized. And that came from the beginning in the 1950s when nuclear reactors were first built. The Cold War mentality. So, which of course began with nuclear weapons, was passed along to the civilian uses of nuclear power. And as far as health was concerned, the regulators, which at the time was the Atomic Energy Commission, later the NRC did a couple of things. They in their regulations, they made no. Her vision. There was no mandate to do any sort of studies of health near nuclear plants. And the other thing they did was they set what was called permissible limits, that they would require testing of levels of radioactivity and radioactive releases around the plant if it fell below a certain level, the permissible limit. That was not just evidence that the plant can continue to operate, but to them it was a check that health was not being affected at all. Unfortunately, this this is really not very, very good science with something as new and certainly with dangers as well known as radioactivity.

Joe: Studies had to be done. But they the issue was rigged from the beginning. So for decades, nuclear reactors operated and almost no studies were done. There were a few done of workers, health of workers, but none near nuclear power plants because they were run by private companies, private utilities under no obligation to do studies and to share information with the public. We get to the 1980s, and that's when two of my colleagues, Jay Gould, a statistician, and Ernest Stern Glass, a physicist, decided to create our PFP because of this great dearth of study on the health issue in the 1980s, a couple of things were going on. The eighties were came right after the 1979 meltdown at Three Mile Island, which was the worst accident among nuclear power reactors in the US. Maybe, maybe not. Maybe not all reactors. You, of course, know about the Santa Susana plant, which research reactors and that terrible 1959 meltdown, which may have been worse anyway in the 1980s. The three mile accident was followed by a barrage of articles in medical and scientific journals, 32 of them, in fact, which addressed the mental health and stress related issues caused by the three mile accident. There were four for almost 12 years. There was not one single article published that actually showed how many cancers or how many infant deaths or whatever were near three mile. And it was it was it was quite disturbing.

Joe: Also, in the eighties, there were the first that I know and maybe there haven't been many more since, except for our work. Two articles about cancer near nuclear plants in the US. One was 1983. A UCLA public health professor named James Engstrom did it, and he found that near the San Onofre. Well plant. There was no evidence of any increased risk of cancer. That was it was published in the American Journal of Public Health. It was followed by a letter by Dr. Carl Johnson, who was a health director in Colorado, who criticized instruments, his methods that he used. Then maybe more importantly, there was an article in 1987 by Richard Clapp from Boston University, and he found that near the Pilgrim plant in Massachusetts, what, there was an elevated level of leukemia. And because this is a Massachusetts, that article got to the desk of Senator Edward Kennedy, and that prompted Kennedy to write a letter to the NIH director and his letter. And I have copies of the letter and the response. Kennedy said it would be appropriate if the NIH could address the issue of a causal connection. And within three weeks, the NIH wrote back saying, we are conducting a cancer county based cancer mortality studies from the 1950s to the early 1980s. And everybody and I'm sure Senator Kennedy as well, was surprised. Oh, we didn't know. But obviously with Kennedy's position, they moved on it. The this again, this is the first. And to this day, the only published study by the federal government on cancer, new nuclear plants, it's it was published in 1990 and very briefly the.

Joe: Conclusion was there is no connection between the opening of nuclear plants and increased local cancer rates. I've gone through that study many, many times. There is there are a number of places, including San Onofre, which showed an increase once the plant began operating. So it was at this point we decided to do our to start the group. And since then we have produced, as Peter has told you, 3038 medical Journal articles. There is a 39th that's been approved. It hasn't quite been published yet, but we'll very shortly. Basically what we found in just a few words is that in most cases in the county or counties closest to a plant, when it opens the cancer rate compared to the US, which typically are roughly the same goes up. I mean, the gap between the local and the national rate grows and grows. And I found this in numerous at least a half a dozen cases. Number two, we've done studies showing that when you close the opposite, when you close a nuclear plant, that immediately there are sharp declines in local infant mortality and local cancer rates in children under the age of five and longer term drops in cancer among all ages. So which is which is well received because we're concerned that we're doomed with a nuclear plant if closing plants is a benefit to public health. And finally, the thing that we're probably most noted.

Joe: Or is the baby to study? Again, the regulations are weak. There are no requirements that the government should. Study levels of radiation in bodies, but we have done the only such study and are in the process of expanding it. We've looked at over 5000 teeth in children living near, near to and far from nuclear plants. We found higher levels in the ones that live close. We've found that they are rising over time and we found that there is a connection with childhood cancer. When one goes up, the other goes up and one goes down, the other goes down. So and as you heard, we are taking this study to a second level where we're going to compare the strontium 90 and teeth of children living in our nuclear plants. The first one will be the Fermi plant near Detroit. We're going to compare them with teeth from people who gave to teeth in the 1960s study people who were exposed to bomb fallout early in life. We're going to ask the question what was greater? The people born in the in the fifties and the sixties who got bomb testing fall out early in life, or today's children who are getting reactor emissions early in life. No one's addressed that. We're going to find out. So. I hope I made my 10 minutes or 15 minute goal here, but I'm going to stop. And I think this is a good time to just open things up for comments and questions, which I'll be very glad to answer.

Peter: All right.

Joe: Comments and questions. Ali.

Ali: I was wondering, do you take into account and I'm sure you do, that cancer takes decades to develop. You never can be years. It can be decades. Is that part of the study as well?

Joe: Yes, that's a very good point. People think that you're exposed to radiation and cancer occurs in the next year. No, it can be decades. You're absolutely right. And as I described to you, very often we see when a nuclear plant opens and the cancer rate, which may have been the same as the national rate or even below it. Oh, for the first few years, five years or so, there really is not much change. But after about five years or so, up it goes and the gap gets greater and greater over time. 20 years later, 25 years later. So the answer is yes. That is that is a key point. Joe, is the.

Peter: Is the national rate. You're most.

Joe: Appropriate comparison variable because it could be that.

Peter: Many other things such as radon or industrial waste or whatever.

Joe: Could contaminate that.

Peter: How about have you entertain using a comparison group that is free from those other exogenous sources of carcinogens?

Joe: Very good question. And even if you kick politics out of it and make it a serious study, it's choosing a control or an unexposed group is tricky. Now the US rate is really a very quick and convenient way to do it. Most of the US does not close to nuclear reactors. However, we are a cancer society. 40% of us are going to be diagnosed sometime in our lives and more will have it and not be diagnosed. So that's not always I mean, it's a start, but it's not always the greatest way. Another way to do it is to try to find if you're if you're say you're doing a county to find control counties in the same state that were not exposed, counties that are that are the same in terms of demographics, the racial composition, the age, age breakdown and so on, poverty and unemployment and issues like that. In the in the 1990 NCI study, National Cancer Institute study, I mentioned they did pick control counties, for example, San Onofre, which is the one I know you're most interested in the study counties. The closest counties were San Diego and Orange. They pick three control counties and tour San Bernardino and Santa Barbara. Now, I know it's a tough thing to do, but Santa Barbara is very close to the Diablo Canyon, the nuclear reactor and downwind. And Ventura County is the location of Santa Suzanna. Now, you know, maybe the maybe the age, race and sex distribution was the same, but as far as, you know, a nuke area versus a non nuke area, I have great concerns about that. So the answer is yes, it's tricky, but the best way to do it is try to find a similar. County in the same state.

Peter: You know, one of the problems with that study is that in the same county, like in Orange County, they counted River River, not Riverside, Fullerton, which is 40 miles away. And and San Clemente, which is two miles away. They counted in the same because we're in the same county. They didn't use distance. They used they use political boundaries. That was a terrible flaw in that study.

Joe: Yeah. And, you know, again, but I appreciate it's a tough thing to do. And that's why we have done studies like what happens before and after a nuclear plant operates in an area or after, after one closes. All right. The you have your control before a plant opens. It's not. Operating. It's not emitting radiation after it is. So we have used that quite a bit because of the difficulties in finding a real control.

Peter: Nancy has a question. Go ahead, Nancy.

Nancy: Hi. Just to follow up on the fact the cancer is it takes a while before it developed, you said that after plants closed the cancer rate goes down. I'm hopeful because a new point just closed. But how long does that take?

Joe: Well, Nancy, we've done two sets of studies. The first one was we looked the first two years after a nuclear plant closes compared to the two years before. And we look specifically at the youngest, you know, the infant mortality, you know, children who die in the first year of life. And we looked at cancer that was diagnosed in children four years and younger. And that's where we looked at eight plants, which closed during the 1990s. And we found that in every single case, the there was a sharp decline in both infant deaths and child cancer cases in the counties closest to the plant. Now, as far as the longer-term effects, we did an article about ten years ago. We looked at the Rancho Seco plant, which is just outside Sacramento. We've done a lot of California work, as you can see. And we looked at the local cancer rates just before Rancho Sago stopped operating and over the following 20 years. And we found that as time went on, the gap between the county rate and the state rate closed and the county rate became lower, we estimated in 20 years 4400 fewer people developed cancer as opposed to if the pre shutdown levels had had had continued. So yeah, there is certainly evidence and again these are all published in peer reviewed journal articles.
Nancy: And just do you know about how long after exposure what's the normal. For cancer after exposure. Is there any normal.

Joe: It varies. You know, I mean, sometimes it's it's quick. It's in the following few years. But again, it can go decades. I mean, there's still doing studies on the survivors of the Hiroshima and Nagasaki bombings, which are now 77. Years in the past, and they're still finding new cases of cancer at higher rates than expected. So it could go it could go decades.

Peter: Sara.

Sara: You know, my I just have a general question. What sort of. Where do you experiencing as the impediments to getting this information out? It looks like you have such valuable information about the impact of nuclear plants when they're built and when they go away. What are you experiencing as the impediments to getting this out to the public gets it.

Joe: Impediments are. I hate to say it, we are a relatively small group, like many non-profit charities, and we are strongly dependent on contributions from individuals and from some foundations that see the the the importance of this. We we get no government money whatsoever. Most research in this country is funded by the NIH. The government, as you can see, there is no hurry to part with a dime to allow this research to be done by an independent group like ours. And that's that's also why you don't see much coming from university based professors. They're all intelligent. They all are experienced in research. And they understand that radioactivity is dangerous. But they dare not do this because there is a history of esteemed. Academic academicians and researchers taking a huge political hit for. For doing studies that. That show that there is a cause and effect. And I'll quickly give an example. It was the original example because in the 1950s, a British physician from Oxford University, Alice Stewart, was given the assignment to take a look at the childhood leukemia in England. And find any kind of patterns. And she looked through the data and she found nothing. But she found one thing that was odd.

Joe: She found that of. Of children who had had whose mother had had a pelvic x ray during the pregnancy, had a much higher chance of developing cancer by by age ten. It was like a ten times higher chance. And she published this Lancet in the British medical journal, and she was absolutely shocked to bits by the scientific community as well as government. Of course, that this couldn't possibly happen. The levels were too small because this was something that physicians did in those days as a as a routine, just as, you know, just as a diagnostic tool, just to see how big the child was before birth and where the feet were and where the head was. They would do an x ray. Now, when you hear that story, we are horrified. My God, we would never do that. We do ultrasound with no radiation. But it turns out that after years of of fighting and continued use of pelvic x rays, they finally gave up and said, You know what? We have ultrasound. We can do ultrasound. But it took more than 20 years to to make that change. So that's that is our biggest obstacle.

Peter: Roger, you have a question?

Roger: Good morning, Joe. And we all owe you a debt of gratitude for the work you've been doing, not just recently, but for decades and decades. And please keep it up. I have a question. I think one of the biggest shots that we have for this whole issue is with the National Academy of Science Study, which is now stalled. And it was defunded by the NRC in 2016. And now, thanks to Michael Leavitt and Katie Porter and some others, it was funded and now it's blocked by HHS. And I'm wondering, is this Secretary Becerra's personally or is who's leaning on Becerra? Is it Biden? Is Department of Energy? Is it is it the Department of Defense? And who is blocking this? This is a long reach of the nuclear industry. I'm wondering if you have any connections or inside information. I do talk to Oliver Edelson and Mike Levin's staff. He's intimately involved with this and they're going to have a workshop sometime in the spring and talk about it some more. He says there's not enough known is premature to do a study. That's what they said. That's totally ridiculous. So he's been proposed for over a decade, but I don't know. Do you have any inside information? Please share it with us in the future months if you do. Thank you.

Joe: You know, I purposely didn't bring this up in my talk because I knew you were going to write yourself. So thank you. For those that don't know very quickly after that 1990 National Cancer Institute study, there have been no more federal studies of cancer nukes. However, in 2009, out of the blue, I think everyone was surprised. The Nuclear Regulatory Commission announced We have given a no bid contract to Oak Ridge associated universities in Tennessee to do a study of cancer in nuclear plants. I mean, everyone was surprised. But once the shock wore off, the immediate response was, first of all, Oak Ridge is a weapons defense town that that that and Hanford and Los Alamos were the three plants where they made the original atomic bomb and have continued nuclear weapons work since they can't possibly be objective. And a big stink was raised. Oak Ridge was quickly withdrawn and another contract, another no bid contract given to the National Academy of Sciences. And after six years and $10 Million, I think my figures are roughly right. The NRC decided to scrap it to terminate the study. I think the key point here is the NRC has no business. Being involved in commissioning health studies. They have proven time and time again and even before they came around when the Atomic Energy

Commission was regulating plants, that they are biased in terms of the plans. In fact, most commissioners at the NRC are former workers or former engineers and physicists at nuclear plants who, after their stint at the NRC, are going to go back. They can't possibly object. And then they also are not health researchers. You understand that? Again, I think that Roger, I don't know that the details of what those people you mentioned of what they're doing and the chances of getting studies, It's but to hear, like you said, that HHS is blocking a reopening of this study by us, though it might be is just more evidence that we can't get any good information from the government. It's got to come from independent sources such as our group. Any thoughts on that, Roger, or others?

Peter: Well, I think you can trust the National Academy of Sciences. They're theoretically independent and have a long track record. What I'm wondering is who's blocking it? And there's got to be somebody knows this is a widespread and I assume it's the Department of Energy.

Joe: That would be my guess.

Roger: Is touring the country, promoting nuclear energy and to keep calling it clean and reliable and cheap and just lies like that all the time. And she does that. Department of Defense doesn't do that. But I'm sure they're a big factor, too. And I would guess, you know, I'm tempted to write to Joe Biden if I could ever find how to write to her. And because I think Biden probably does what he's told and the pressure is on to we need to have an answer to the whole climate change problem and the whole energy problem. And nuclear is the solution. And I think this is a very dangerous trend that's going around nuclear as a solution. And we've got to stop this. So somebody's got to find out why Becerra and HHS is blocking the study. They have the money. It's ready to go.

Joe: All right. Yeah, well, we know that they have been they have obstructed this spore kind of work for a long time. And now most recently they have, because of the effort to address climate change with safer forms of electricity, they have somehow taken the word nuclear and put the prefix emission free in front of it because nuclear plants don't. Don't release greenhouse gases. First of all, they do release greenhouse gases to some extent. Second of all, the process of getting going from uranium in the ground to a nuclear power plant involves multiple steps, all of which are very filthy and all of which release huge amounts of greenhouse gases.

Roger: So they never talk about they never talked about that. Never. They ignore it.

Joe: And they've been able to take that and parlay it into bailout monies from numerous states New York, New Jersey, Illinois and Connecticut, and now California. Regardless of who which party the governor is at all, and the states passed bills addressing climate change and most of the money that comes up is given to nuclear companies in New York over ten years, $7.6 billion and in New Jersey and other billion in California, 1.5 billion. It's just crazy. And now, of course, the federal government with its. With the I forget it's the Inflation Reduction Act or the infrastructure bill has put in lots of lots of financial goodies for nuclear plant, which is going to make our work harder. But that just means we have to. Ali, you have here.

Peter: Can I just add one more thing? The other big.

Joe: Thing. Go ahead. Ali, you're muted.

Ali: Are you are you measuring exposure to nuclear waste dumps as well?

Joe: Uh, no, we haven't been able to. Again, we're a small group and they're limited as to what we can do. We're most concerned with the actual releases, routine releases from nuclear plants when they're operating and how much gets in the body, the strontium 90 and the baby teeth, and what the changes in rates of local cancer and other diseases occur that keeps us more than occupied. But we would love to get it to waste. That's another enormous issue.

Ali: Yep. Thank you.

Joe: Diane

Diane: Diane. Hi. Yes, sorry. Hi, Joe. I was going to ask about I don't know if you have any information regarding, as you know, here at Holtec is planning to dump over a million gallons of radioactive water from the spent fuel pool. Do you have any comments on that?

Joe: Yes. Don't do it. It is it is just almost hard to believe that something like this would be would be contemplated. Excuse me. And again, the point I'll make here is that unless people put in an enormous. You know grounds up. Grassroots effort to stop this. The government officials in charge are going to let it happen. The NRC is going to let it happen. The state Radiological Safety Bureau will let it happen in a way not that I don't blame the nuclear companies or Holtec for doing what they're doing there. They're private companies to earn a living and trying to live within the regulations. It's the regulators that that are the issue here. We put our trust in them to keep people safe and they're not. And we've had a long, long history that they haven't been. That's my comment. Michelle.

Peter: Michelle and then Bart. Hey, Michelle.

Michelle: I just wanted to shout out to Joe on the fact that he's one of the people that helped close Indian Point in New York and back when after 911, when the Indian Point issue really reared its head because of the attack and Entergy was gearing up for relicensing, the Westchester County Board of Legislators Commission, Joe and our VP to do a study on cancer in Indian Point area and he did excellent study and he looked at Indian point is really sort of right near three different counties are within a few miles so he looked at did a comparison with those counties and with other areas of New York as well as with national cancer incidence. And the findings were actually staggering. I mean, it wasn't just like, oh, another 5% more. It was like some forms of cancer was in the 70% greater one. I think one of them I can't remember which off the top of my head, maybe childhood leukemia was like 90% higher. I mean, the numbers are incredible. So the industrial industry, of course, came out with its PR, but this is what was so telling. So Entergy was at that point an $11 billion company that was still making a lot of profit from Indian Point. They did not go against the findings. At all. And that is really what the telling point is, if you have a lot of money. And you can. And damaging information comes out that could literally stop your cash flow. You're going to fight it the best you can. They didn't even try. So I just wanted to let folks know about that.

Joe: You know, the line we always thank you for those nice words, Michelle. It was it was fun. It was very rewarding seeing Indian Point, Carlos, We and many others did a lot of hard work. The comment will make here is that we always say, you know what? Please. Do studies and please show evidence, show proof that nuclear plants are safe. All right. Rather than just saying your study is wrong and everything is fine, just because releases are below a certain level is not enough. But that's the way the game is played. They want to play it out on political and PR terms rather than on evidence.

Peter: Hey, Bart, you're next.

Bart: Oh, speaking of PR, Joe, this is a copy of your book. So everyone can help support you by buying a copy and reading it. I have a copy. It looks too new. I should have been reading it then. Thank you very much for coming. And I have a quick question. I want to thank Ace and stuff for all the all the work he did to help launch this. But oh, yeah. Do you look at different kinds of cancers? I mean, do you I mean, I don't want to get into weeds too much, but there are all these cancers. I know leukemia is a primary one. And then the second question is, anyone you know has looked at cardiovascular disease, because I remember Kate Brown was always talking about heart disease, cardiovascular disease. I don't want to get into the weeds, but thanks a lot.

Joe: Again, I'd like to be a larger group of so we can have somebody looking at each type of cancer. The answer is we have done studies not just of all cancers combined, but of particular cancers that are known to be sensitive to radiation. And the two, I'm going to call it, aside from leukemia, which you mentioned, are child cancer and thyroid cancer. We know that a dose of radiation. Absorbed by a fetus or an infant or a young child is far more dangerous than that Same dose to an adult, a fully grown adult. And really, of all the studies of radiation, of all types of radiation, child cancer is the most popular one. They're kind of the canary birds. If you see if you see an increase in child cancer in an area that's been exposed. That's strong evidence. The other one I'm going to point out is thyroid cancer. Now, thyroid cancer is not a very high profile cancer. It's not that common, not nearly as common as lung or breast, colorectal. And it is generally most treatable, although every case is grueling and awful. And some do die. You know, if you go to the on Google and if you look at the Mayo Clinic or the Cleveland Clinic or the thyroid cancer, they're going to say, what are the factors behind thyroid cancer? If you've had a previous thyroid disease or if there's a family history of thyroid cancer and. The list quickly ends with exposure to ionizing radiation, specifically radioactive iodine, which is one of the many different chemicals that nuclear weapons and plants produce. We found some bad, bad thyroid cancer results. And the one I'll point out is what Michele was talking about near Indian Point in the 1970s as they were building these two large new nuclear reactors at Indian Point B, the four county thyroid cancer rate was below New York State.

Joe: I don't know what was. Goodness. 20% below or something. And within 30 years it was 50% higher. I mean, it just staggering. It was going up. It's gone up everywhere in this country. But near any point, it was it was overwhelming. It was overwhelming. So, yes, those are those are the two that we try to pinpoint as best we can. Oh, I'm sorry. And the heart disease part.

Excellent question. It's not just cancer. Radiation does a number on the entire body and affects not just cancer, but other diseases. After the Chernobyl meltdown years later, in 2009, there was a book published by Alexei Yaakob and his colleagues, and the editor was one of our major colleagues, Dr. Janet Sherman. She edited the book. This book consisted of 5000 articles that had never been published before, mostly, and were in Russian in the Russian language. They found that near Chernobyl, in Belarus, in Ukraine, yes, there were all sorts of increases in different types of cancer, but there were increases in heart disease and in digestive diseases and in lung disease, respiratory diseases, and on and on and on. It did a number on every everything. And the final thing to say about heart disease is there was another great mentor and inspiration to, I think, all of us, Dr. John Goffman, who worked on the original Manhattan Project for the original atomic bombs. Later on in his life, he turned his attention to cardiovascular disease and radiation, and he's not that well as well known for it as his previous work opposing bombs and reactors. But. Suffice it to say, yes, it is. It's a major. Call can be a major cause of heart disease.

Peter: Ace your hands up.

Ace: I just wanted to mention that I was sent a pre-publication copy of that book and made corrections throughout because there was a lot of typos and a lot of poor translations from metric to others, etc., etc. a lot of errors in it, but it was absolutely overwhelming what its message was. There was. You just could not deny it in any way, shape or form. It was amazing. Unfortunately, I didn't get the changes in in time When I sent them in, she was like, Oh, it's too late by a week or so. But what a book.

Joe: Yeah, I mean, look at that area. Not a tiny area, but a larger one went before the melt up. Went from 20% of children were unhealthy and 80% healthy to just the opposite. 80% had some major condition and only 20% had escaped. I mean, it's just staggering. Well, Joe has.

Peter: Been very generous with his time. Do we have time for a couple more questions, Joe?

Joe: I have to drop off in about within 5 minutes. All right, Ali, you.

Peter: Got a question? Oh, you're.

Joe: Muted.

Ali: Are some people more resistant to radiation? Radiation than others?

Joe: I'm sure they are. What? What makes you resistant?

Peter: Being male.

Joe: Yeah. Yeah, I think it's probably. I don't know. I don't think anyone knows, but I think it's probably that. That list of basic things your doctor tells you, you know, eat, eat a good, healthy diet, get exercise, and, you know, get plenty of sleep and have low stress and hopefully have good genetics. Yeah. Some seem to. Not be effective nearly as much.

Ali: Well, the reason I was asking, I had over 5000 rads. I have my records as a child to shrink my adenoids. And the outcome was I do have a benign so far. Thank you. Tumor in my sinus. So I don't have very much sinus. But they said that's what it's from. And I also had the pelvic x rays when I had my first when I was pregnant with my first child. But so far I shouldn't say anything. Knock on wood.

Joe: Well, in public health, we talk about risk. You know, it's not like a guarantee that it's going to harm someone. But we look at a population basis over large groups of people. Will it harm will cause more harm than if it hadn't been exposure.

Peter: I'm going to take two more quick questions. Susanna Golden and then Daryl.

Susanna: Thank you. Thank you, Joe, for everything you do for those of us here at Indian Point dealing with this issue of whole tax desire to dump all of the spent fuel pool water into the Hudson River that supplies upstream seven communities with their drinking water. And Paul Blanch having confirmed that there is nothing that can be done about it, Donna Gilmore feels that only leaving the spent fuel pools open with the water in it is the way to store it. But, of course they're not going to go along with the millions of dollars a year to keep the pools open. What is your advice to us? We were hoping that we could store it. We could ask for it to be stored in tanks on site instead of dumping it. But is that not a viable thing to ask for? Will there be corrosive elements in it that will eat through the tanks in time? We can't seem to get anywhere with this issue. If you could shed any light, I'd appreciate it.

Joe: I wish I had an answer. I don't think there is a good one. But I will say that anything, anything has got to be better than introducing large new amounts of radioactivity into an active source. Such as the Hudson River. That is that is just wrong. Keep keeping it in in pools and in dry cask and all is a challenge enough? But at least it's not directly, directly circulating, at least so far into the biosphere.

Peter: Ok I've got Daryl is the final question.

Daryl: Hi. Thank you very much, Joe, for this very enlightening and very depressing extra group glob of information. I was just reminded through your talks when you were talking about the nuclear industry in terms of nuclear weapons. There was a book. It's probably at least 15 years old and maybe somebody else has either read it or heard of it. And I think it was called something like the clan of one breasted Women. And there's a whole town somewhere, either in Nevada, New Mexico, where almost all the women have breast cancer because they were so near the site of the nuclear bomb tests. And I was just wondering if anybody else have heard of this book or know of it. And I'm going to try to research where this book is, because it was just the people just so matter of fact felt like, well, this is just happens because we needed it for our defense.

Joe: Well, I've heard of the book. I've not read it. If you do come up with it, you threw through. Perhaps Bart could. Could let me know. I'd be interested in seeing what it's about. Yeah, but that's. That's just typical of the. I'm not going to blame people for saying, oh well, that's, that's, you know, cancer is in our society. No, I point the finger directly at our leaders who know better and need or not need to, but are obligated to protect our people from health hazards, especially one as dangerous as this is really, arguably, these are the most dangerous chemicals on the planet.

Peter: Hey, Joe, thanks so much. For sharing your expertise with us. And thanks for people from both the San Diego and Orange County and others across the country that have joined us for today's Zoom. It's been quite enlightening and we greatly appreciate it.

Joe: Thanks so nice for having me.

Ali: Thank you, Joe. This was great.

Peter: So I'm going to turn it back to Liz our moderator for a few final words. There she is. You're muted. Liz your muted. I'm going to get a shirt instead of.

Peter: Saying Sierra Club. That says you're muted nude.

Liz: I'm okay now. Right?

Peter: You're okay.

Liz: So thank you very much. This was. I was terrific. Are there any final? Reflections or comments before we sign off. And when's our next meeting? Does anybody remember? Just two weeks from now. If anybody wants to join us, let us know. Thank you so much.

Peter: I think we should not be in sync with the national meeting, which meets in two weeks, too.

Liz: We'll have to work on that. James. You have your hand up. Well, okay, I guess.

MaryBeth: Sorry. Sorry. This is Mary Beth, And I just wanted to say that Terry Tempest Williams wrote *The Clan of the One Breasted Women*, and it's about her family in Utah. Downwinders. We've got it if anybody wants to borrow it. So is that it? And thank you so much. Yeah. Yeah.

Liz: This was great. One of the best.

Joe: Thank you.