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THE WORLD IS THINKING

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Good evening. I'm Stuart Brand from the Long Now Foundation. Let's bring out our speakers, Peter Schwartz and Ralph Cavanagh. The format is not a debate. That is, it's not going to be a deal where you or anybody but I guess your innermost thoughts decides who won and who lost. You do get to choose who goes first. We'll get to that in a minute. The format is as follows. Whoever goes first will stand up and hold forth on their topic and their point of view for fifteen minutes. And we'll be pretty strict about that fifteen minutes, so that we're even. Then the second speaker, in interview mode, draws that person out even more on their point of view. And then the second speaker has the job of summarizing the first speaker's viewpoint to the satisfaction of the first speaker, who has to say, "That's right, you got it. I can't believe it, but you got it." And then they reverse roles, and it goes the other way. Is that clear. At that point, we will be collecting your questions and we'll start to get into more interaction completely here.
Now, first we decide who goes first. This will be a show of hands. You're welcome to shout if you want to, it doesn't make any difference, we're just looking at hands. And how many want Ralph Cavanagh to go first? All right.
Put your hands down. How many want Peter Schwartz to go first?
What can I say?
Interesting, what is this telling us. Okay, let me just say a little bit about-- while Schwartz is collecting his thoughts now that he realizes he's not in the repost mode. Schwartz is well, he was at Royal Dutch Shell for five years. So he's got oil company experience. He speaks richly with people in government all over the world, in corporations all over the world, non-profit foundations as well. But I will tell you what most interviewers don't do, which is that he was SDS when he was a student, at Rensselaer Polytechnic Institute, then he was a volunteer in the Peace Corps. And I first met him at an Earth Day kind of event that he helped organize at UC Davis. He has green credentials. He was on the board of the Rocky Mountain Institute and is a long time friend of Amy Liebowitz.
And he has been in the thick of energy for basically his whole career.
Ralph Cavanagh, who will go second, is from Yale, trained as a lawyer there.
And is the energy specialist with the National Resources Defense Council, which for many of us is the most respected environmental organization going. It bases what it does on real science, on real technology, and it really knows how to make politics work. It's a real honor to have him here tonight, as well. These two know each other, and they know each other's strong points and weak points, and they will go on collaborating and competing in the future, so this is part of an ongoing story. Starting with Peter Schwartz.
Thank you, Stuart. And I want to thank the Long Now, my colleagues and especially Ralph, who is, as Stuart said, an old friend, and I must say I want to thank all of you. I'm astonished. I thought maybe 12 people might show up tonight. I know many of you are Long Now regulars, and so I'm very pleased that you've all chosen to come and join

us this evening. I think it's a very very very important issue that we're talking about, here.
And Ralph and I have been on the same side on many many many issues
over many years and will be again on other issues, but on this one I think we
have some disagreements, and I think that's what we're here to talk about.
Because I think the reason we need to use nuclear power is that the risks of really nasty
climate change much sooner than we think is much greater than is widely believed and
that that climate change is at least in part driven by our rising use of fossil fuels and especially
coal and oil, and that that in turn is being driven by rapidly growing developing countries,
especially countries like China, so in my view we need every alternative to coal and oil, and
we can't afford to leave off the table anything, particularly since the risks are of nuclear
power in particular, are likely to fall. So the risks of climate change are very great, and the
risks of nuclear power are declining. So that's the fundamental position.
Now before I get into the climate change part of the story, there's one small piece
of the story that is worth spending at least one minute on, but I suspect Ralph and
I will agree on this and are not going to spend much time on this, and that's the oil issue.
Because of course oil is another source of CO2, but in fact I think this issue's going to be pretty
much taken care of by itself, because over the next 50 years we're going to run out. Or we're
going to hit the peak and it's going to go down. The pessimists think the peak is now,
the optimists think it's maybe 30-40 years in the future. I count myself as one of those,
but in any event, we're going to have to make a transition away from oil over the next half
century, no matter what. Irrespective of what our issues are about climate change or
anything else. And furthermore that as we begin to feel the pressures of that running
out, the price of oil is likely to go up, so we'll have the benefit of rising prices to force us to
change our behavior, even if we're not smart enough to do so on our own.
So by and large, we're going to move away from oil as a transport fuel. We've already
done it in electricity. But there is a further implication for climate change because this is where
it leads us next, is that many of the alternatives to oil involve electricity in one way or another.
That is, we may use electricity to charge batteries on cars, though I think that's
less likely. More likely is we'll use electricity to produce hydrogen, which we'll use as a transport
fuel. And that may require a good deal of electricity. So the shift away from oil is also likely to
increase the amount of electricity that we use, and we're going to have to make the shift away from
oil in any event. The real issue here is electricity. And the real issue behind it,
the thing that we are most concerned about, is climate change.
And the conventional wisdom on climate change is that basically what we have is a situation
of partly natural but mostly human induced, mostly by the use of fossil fuels, we are
seeing a gradual rise in the temperature of the earth, and that this will take place over the next
several centuries and we'll rise maybe 3, 4, 5 degrees a century, and we're not going to
like the consequences, especially if you live in the Maldives or Bangladesh, places like that, which
will progressively disappear under rising seas. Now, that could happen. That's possible.
But I think there's a much worse scenario that we face, and a far more likely scenario,
and that the science and the evidence is pointing us in that direction. And you get a hint
of it by looking backwards, and that is that what we face is the possibility not of several centuries
of gradual global warming, but abrupt climate change. That is, rapid changes in our climate
as we've experienced many times in the past, changes of 5, 10 degrees over the course of a decade,
not centuries. And that it could become very volatile. And that that warning in fact oddly enough

could trigger coolage. And without going into all the mechanisms by which that happens, gradually as the earth warms, you see what's already beginning to happen, polar ice melting, glaciers melting, and so on, fresh water flowing into the North Atlantic, affecting the currents that move huge amounts of heat around the earth and that gradually produce the temperate climates that we all experience in the upper parts of the earth. The northern latitudes.
If the earth warms rapidly, one of the results is that we could see the earth cool, as has happened many times before. And in fact the greatest risk we face is not merely gradual climate change, but a return to the normal climate of the earth. And that's what this is showing us. What you see here-- ah there we go. This is the last ten thousand years of human history, all of human civilization. We could in fact settle down when the earth's climate stabilized. We could have agriculture, we could have the development of cities and so on. All of that took place in the last 10,000 years, after really serious global warming. By the way, you see this is about 20 degrees centigrade here. So it's a lot of movement.
This is the normal climate of the earth. Very volatile, and much colder.
The risk that we face by rapidly rising CO2 production in the atmosphere is not a warmer earth. It is a return to the normal climate to the earth. An end to what we call the interglacial. These 10,000 year periods that happen every quarter million to half a million years of relative stability. The risk that we face is that if this happens, we face a very dire prospect.
And that dire prospect is very simple. This could support eight billion people. This may be two. Six are going to have to get off the planet. And the way they get off the planet is war. This is a recipe for war, and that's what I'm most concerned about. Is that if we fail to deal adequately with the abrupt climate change challenge, we will find ourselves in a rapidly declining carrying capacity of the planet and an inability to support the people of the earth.
Now, we did a lot of work on this for the Pentagon a couple of years ago, and what we could see then was the evidence that this was increasingly coming true. We were already seeing freshening of the North Atlantic, we were already beginning to see some of the fluctuations in the current, we were seeing it in the climate history, we were even seeing some recent indications in the last year offshore California, the absence of a salmon season most of the year was due to the lack of an upwelling from the Pacific, change in the currents there. These are the conditions and early signs of an abrupt shift. And it is not guaranteed, it's a risk, it could be wrong. But the risk is rising that that is what we face.
So I believe that in fact the real risk here is that our civilization is at risk. This is not simply a small matter of a few countries and a shift in the agriculture pattern of the world. This is our very civilization that is at risk here. So.
What's driving this climate change, and is there anything we can do about it? I mean, some of it is natural, probably. But most of the evidence suggests that it is in fact human activity that is producing the particularly rapid change that we're experiencing.
Now, in particular the fossil fuels that we're burning, putting CO2 in the atmosphere.
And in fact, having now talked before about oil and transportation fuels and so on, and suggesting that some of those are going to become part of electricity, the story really is electricity. It's how are we going to produce the electricity that we need around the world to light our homes, heat our homes, drive our factories, and even ultimately probably drive our cars, without producing vast amounts more of CO2.
So it comes down to energy. And in fact how do we produce our electricity. It's more about coal and oil. And getting rid of that. And most of that is being driven by the

developing world. That is, today's level of CO2 output, we produced. But most of the growth yet to come is to come from the developing countries. And you can see it in this graph here. This is the growth and energy demand over the next 50 years. Starting back here in the 1920s and the 30s, what you saw was energy production was about a quarter of today, but it was mostly coal. Very heavily coal. Over the last sort of 50 years, we've quadrupled our energy use, we've added oil, natural gas, a lot of big hydro, and a bit of nuclear power to that. If we are very efficient, we'll only double our use of energy in the next 50 years. But if we continue the way we're going right now, we'll again quadruple it. Now we'll add a lot of renewables like wind and solar, but that's a lot of energy to supply. And the blue is the rich countries. What we call the OECD. The yellow are the developing countries. China, India, everybody else. And as you can see, most of the growth is to come in those places as the next 2 billion people get rich. One of the great achievements of the last decade and a half, is about a billion people climbed out of poverty in places like China and India. And if we're lucky in the next 50 years, another 2 billion will. That can't be a bad thing. That can't be a bad thing, for those people to climb out of poverty. But if they all live the way we do, we're in deep trouble. So.
Where is all that electricity produced? It's produced by coal. Today, and here's what would happen in about 30 years if we don't do something. Lots more coal, not much more oil, a lot more gas, this is the challenge. And look, that shows a lot more renewables, even there. Many fold increase. The issue is the CO2. So this is the emissions from the different fuels, and what you see is a steady increase from coal, steady increase from oil, we're going to shift some of that to coal, and even some more from natural gas. The challenge here is how do we get rid of this particularly, this will begin to get rid of it by itself, and this is the cleanest of the fuels. The challenge we see is in China. There we go. China's energy demand is set to grow again from about 47 quadrillion BTUs to about 140. It'll triple if it keeps going the way it is.
The challenge is to get it down here. To improve its energy intensity, its energy efficiency. And by the way, about what the United States did between 1975 and 85. So it's not impossible. The problem is, that most of it's going to come from coal. So what are they going to do to get rid of that coal? And the coal is really nasty coal in China. It's brown soft coal. Skip that one. Now, looking at where the energy's coming from today, this is electricity, and what you see, these are all the different ways you make electricity. Coal's the largest. This is renewables. Of which most of it is hydro, and if you unpack that other 1%, most of that is geothermal. Solar and wind is a tiny invisible fraction today. We need to increase it enormously, but it is tiny today.
So our technology options are cleaning up coal, renewables, nuclear, hydrogen, and efficiency. The point is that economics will determine some of it, and gradually most of it's going to get more expensive. These are the capital costs of it. We're going to have to do basically all of them. And one way to think about it is what you call stabilization wages. This comes from Rob Sokolow at Princeton. And basically, this is the line of CO2 if we don't do anything. That's what we need to do, cut it. And each of these, you can think of as a wedge to reduce it. So if you wanted to do it with wind it would take 2 million 1 megawatt turbans. If you want to do it with solar, it will take 2000 gigawatts, 700 times current capacity. If you want to do it with nuclear, you need to do 2 times current capacity. That's the issue here. How much you have to do if you

really want to get rid of that and begin to lower it.
Does it work? We'll, here's what the situation is in France vs the world. The world, for this GDP, that output, produces about a half a kilogram of CO2 for every dollar of GDP. Using 60% of nuclear for producing electricity. France, which is 78%, produces half as much CO2. So it makes a difference. It adds up, it cuts it in half already. So what's the issue with nuclear? Well, there are four issues. Economics, safety, waste, and proliferation. And the answer to all four is new technology. We've learned a lot over the last 30 years about nuclear. We made a lot of mistakes along the way. The technology we've had has been costly, some of it less safe than it ought to be, and we haven't had a good solution to the waste problem. All of it is now accessible.
We can see new generations of reactors, which are both cheaper and much safer, and likely to be constructed much faster.
So there are a variety of new technologies coming of that sort, and critically, what we see is a new fuel cycle. A fuel cycle that is recycling the fuel. We're one of the only major nuclear countries that does not recycle our fuel. So we waste most of our fuel. We only use 5% of it. Improved recycling leads you to 6%, but the new pyro-metallurgical ones lead you to 94% of the fuel being used. Much greater efficiency. And the important thing is, in the current cycle, you produce plutonium and lock up high level waste that we want to stick into unfortunate places like Yucca Mountain that won't work. The plutonium recycling has much of the same problem with waste and plutonium processing. But the new pyro-metallurgical processes, no waste, or very little waste, and no plutonium produced. So the net result is, safer cheaper no waste no plutonium problem, and you radically reduce the CO2 and begin to address the climate change problem. Thank you very much.
Ralph, you have ten minutes to draw Peter out. And you can use that to get in whatever points you were going to make.
Stuart, I know everyone in the audience wants me to open with the same question. And it goes right to your introduction, and Peter, what we all want to know is, was there really an SDS chapter at Rensselaer Polytechnic Institute? And if so, how many people were in it besides you?
Well, actually one of them may even be here. Is Pete Rotondo in the audience? Another mutual friends of ours who I think was actually in the chapter. And me and Pete and one other guy.
Very good. I want to give you a chance to talk a little more about some issues you had to flash through very quickly at the end. For many in this audience, concerns about nuclear begin with the issue of proliferation, and the fact that as our mutual friend Emory Lovins likes to say, a civilian nuclear industry is among the best possible camouflages for an illicit weapons program. You are talking about, to make a material difference as you've suggested that we would need at least 700 more nuclear reactors worldwide. We now have about 400. Many presumably in places with less than fully stable and effective governments. Talk a little bit about your view as to why we shouldn't worry about that as much as many of us do.
I think we should worry about it. I think it's a real issue. So let me say that I think it's not a done deal. It's a very real issue, we see it today with Iran. It's a perfect example of what's going on. It's happened with North Korea. So it's a real issue, it's a real concern.
I think part of it has to do with the actual technology of the fuel cycle that we use, and part of it has to do with the institutional mechanisms that manage that fuel cycles. So the current fuel cycles are particularly vulnerable to proliferation issues

because of the ways in which they produce the fuel.
I.e., we end up with a fair amount of plutonium in that process, as well as we end up with some nasty wastes that can be played with in unfortunate ways. So part of it involves shifting the nature of the technology of how we process the fuels. Today in the United States as you know we don't reprocess at all. Most of the nuclear countries do. But even their technology I think is still not really a very economic and still produces a fair amount of waste.
So we need to move beyond that technology. Two issues ago in Scientific American it was a very good article, which I can recommend to all of you, on essentially the newer processes, pyro-metallurgical processes that basically enable you to do several things. First of all, to capture more of the energy value of the fuel, secondly radically reduce the amount of high level waste so that you end up with...you still have some waste, but it's fairly low level waste, you don't need to isolate it for thousands of years, and third, you end up with no plutonium in the process. However, you don't get to that for decades.
So we have a problem just running the existing system the way we have it and the current plans for development. So we need institutional mechanisms, probably under the IEA. IAEA, the International Agency for Atomic Energy, that manages the issues of proliferation, to actually help manage the fuel cycle so you don't have closed fuel cycles in any of the countries that you are concerned about. I.e., where they can capture potentially the harmful products that they could use in weapons.
So we're going to need much stronger, much more effective international institutions than we have now.
Absolutely.
A wholly different kind of reactor, a wholly different kind of waste management and waste disposal system.
That's right.
On that point, as you know, an Achilles' heel of nuclear today and one of the things that makes it difficult to move forward is the practical matter, is the political challenge of convincing any particular jurisdiction that this is a worldwide problem, that acceping waste that at least on the face of it looks like a hundred thousand year problem. Is a sensible proposition from the standpoint of local land use management. How would you propose to help them overcome those understandable skepticisms?
Well, I think we've defined the waste problem wrong. That is, the problem of nuclear waste is not a problem of storage for ten thousand years or a million years or a quarter million years or any such very long period of time. The issue is storing it long enough that we can put it in a form that we can re-process it and recycle it. And that is probably surface storage in very strong caskets in relatively few sites, not large numbers of sites, i.e. not at every reactor, but also not one single national repository, probably several, and a number around the world, with it in the mind that you are not putting it in the ground forever where it or in theory forever, where it could leak and migrate and raise all the kinds of concerns that people rightly have about waste. So you're redesigning the way in which you manage that waste, change the nature of the challenge fundamentally, I think.
Okay. Peter, on the issue of how this comes to pass, where the 700 reactors come from, would you use government mandates to get it? Would you-- I mean, talk about how it would happen. As you know, basically the way reactors come into being in the world today is that somebody has to buy them. Normally that's the electric company. Normally there's a competitive process, I'm not aware of any competitive procurement process

any electric utility's ever run in the world open to all sources where a
nuclear plant won. So what's going to change that.
Well, first of all, the truth is that in most countries the decision about power plants are
not a private decision. They are in fact a public decision. They are in fact most
countries with the exception of a relatively few wealthy countries, most of it is public
utilities. So it is in fact a governmental decision most places. No, the truth is, most
countries are not going to build nuclear power plants. So it really is, we're really
talking about 30 or 40 of the relatively larger countries that are involved,
not, I doubt that we're going to have a nuclear power plant in...
You know, some of the larger countries are likely to have it, Pakistan and so on, and there's
an example where you can imagine problems, or some of the other stans. I think it is
very likely that what we'll see is, first of all, most of these plants that we're going to build in
the next, let me say, twenty to thirty years, will be at existing sites. So we're not going
to be confronting the necessity of building the further plants that we need the next hundred
and fifty, two hundred plants that we need, until probably another 30, 40, 50 years
in the future, until we've exhausted all the sites where we can build at the
existing sites. In the United States alone, for example, we have probably 30
to 40 sites which were designed for three and four reactors that have only one or two.
But is it your view that governments should make these decisions, or would you
prefer a more competitive and entrepreneurial process, like every--
Undoubtedly.
--other issue I've heard you talk about.
And the answer is yes, I would much prefer that in the market-oriented
economies, there'd be market competition, no question.
Winners and losers emerge on their merits. And if the nuclear plants can't make it--
Then they don't make it. That's right.
Understood. And that's what I-- Stuart, I know you interrupt me whenever I'm
supposed to restate his position compellingly--
You have four more minutes to quiz and then you ah do that.
Great. Because, Peter, what, as I under--, at the heart of your concern, I suspect you
have this whole audience with you on the seriousness of the climate challenge.
And on the importance of doing everything we can and to end this suicidally irresponsible experiment
we're all conducting with the earth's atmosphere. You believe strongly, I take it, and one
of your graphs shows that even-- I know you take energy efficiency seriously, and the
colloquy I want you and I to have just for a moment is to recognize that
energy efficiency is a resource just like a power plant--
Absolutely.
That you would like to see as much of it exploited as is available and is at reliability and other standards--
We don't make it if we don't do it. I mean you can't get it on the--
What you think that if the world takes advantage of all accessible and cost
effective efficiencies, energy needs will still double by 2050.
On that order of magnitude because of the numbers of people...well,
total energy's another question. Electricity demand will double.
Electricity demand, electricity demand. Okay. Because in part of also the shift away from oil to
electricity as a source for transport fuels.

But if you turned out to be wrong about that, if the potential for efficiency were greater, if the potential for inexpensive renewals were greater, if the competitive process yielded a different set of winners, and nuclear didn't make it, I don't sense great distress on your part.
No. Of course not.
There's no other reason to pursue it in your mind aside from its potential contribution to dealing with the risks of climate change.
Well, if it were cheaper, if it turned out to be, and it could, then that would be another reason, i.e. there would be economic benefit to consumers from that. So given the relative cost, I mean or example, coal, carbon capture and sequencetration could turn out to be very expensive, just to take an example.
But I guess what I want to press you on, sure. And if it were cheap, and if it were safe, and if there were no proliferation problems I think the audience would rise as one and embrace it. But, but, it has nucl-- I want to press you again, are you aware of any case where a nuclear plant in a genuinely open competition against those other alternatives we've been talking about has ever prevailed?
Well, it depends what you mean by an open competition and prevailed. So--
I'll take-- give me the best illustration you--
The answer is, you're basically right, it has been driven by the governments and there's no point in fact in trying to play otherwise. That is in fact what has been happening. That it has been driven by policy and certainly that has been the case until now. No question.
And I think Stuart, one other thing I'd like to ask Peter if I may, is you were focusing on France as an interesting example of a jurisdiction with relatively low carbon dioxide emissions and presenting a different profile for the world on average. You ever looked at another interesting jurisdiction, state of California?
Ah.
So at least perhaps an interesting counter example we could flesh out for the discussion.
Yeah, it would be interesting, what the numbers are here in California.
I think we're getting to the point where you're about to be Peter Schwartz.
I'm Peter Schwartz? All right. So as Peter Schwartz, and it's a pleasure to take on this persona and an honor, look, we are participating collectively, humanity, in a suicidally dangerous experiment with the climate, we are driving up concentrations of greenhouse gases in the atmosphere at historically unprecedented levels, I think the only thing I would have added to what Peter said was as far as I know, the current levels of greenhouse gases in the atmosphere are at their highest point in the last 400,000 years, maybe the last 25 million. There is ample ground for believing strongly that we ought to do everything we can to end this dangerous experiment if we can find a way to do it with reasonable cost. And Peter believes that nuclear power, with all of the constraints and problems it has had historically based on existing technology, can essentially change its spots. Can make a significant and meaningful contribution to stabilizing the atmosphere by dramatically improving its performance in terms of cost effectiveness, the proliferation resistance of the fuel cycle, and the waste disposal problem, which he thinks can be fundamentally be solved by changing the political calculation. Away from an effort to dispose of wastes for geologic eras into a more plausible short term approach based on better technology for capturing the wastes. As a consequence he asks you to keep nuclear power on the table.
I think that's a fair summary.
All right?

Well done!
Thank you.
Now I'll ask each member of the audience to do this.
Stuart?
You're on.
So at the outset I need to acknowledge that I have, since 1979, had the best job in the entire environmental community. I'm the energy program co-director for the Natural Resources Defense Council, which bills itself as a national environmental organization, but let's be serious, two of the four offices are in California, a fifth of the membership is in California. I think that I have heard from a good fraction of it in the last two weeks, giving me advice on exactly what to do this evening. Not all of it consistent. I thought the best suggestion was that I should remind Peter that solar power is a nuclear fuel and if he will just expand his definition a little...he'll bring the audience along with him
Let me explain, I have-- it's my belief and what I'm going to describe is fundamentally an optimistic vision, which I think is actually very much like Peter's was. I don't think nuclear power is going to figure in the near future, not because I'm afraid of it, but because I think there are much better alternatives. Actually, I am a little bit afraid of it, and I'll get to that in a moment. But I believe we can and will do better, and I actually think the state of California is a wonderful proving ground for doing better, and I'm going to talk a little bit about that.
Let me give you a sense of my skepticism, by the way, I accept Peter's statement of the problem. I take the climate change challenge every bit as seriously as he does and I think he set it out about right, we've got to think about the global challenge...I put it this way. I think what we have to do is we have to wean the world from fossil fuels over the next century. Peter ended a memorable article by reminding you all that the Stone Age didn't end when the world ran out of stones, and that's not an impossible proposition, and we've been through things like this before, and so over the next fifty years, my view is that we, and I think this is broadly consistent with where a number of our climate scientists are, we've got to try and stabilize global emissions, and we've got to try to cut US emissions roughly in half, and I don't minimize the difficulty of doing that for one instant. It's a formidable challenge.
And many people who look at that challenge come to the conclusion that Peter does, that Gee we need everything. We need to do everything we could possibly do, we need all the efficiency, all the renewables, all the coal, all the nuclear, we do the coal, we have to pump the carbon underground, we have to do everything. This I would describe is the working philosophy of the United States Congress on every energy policy issue of consequence over the last 50 years. We have to do everything.
There is, I would submit to all of you, an alternative way of thinking about this in a world with limited resources. And that is to say, rather than letting government pick the winners and losers on the merits, which is an idea that in every other context would cause the Peter that I know to recoil in horror, rather than do that here, we ought to be moving toward a paradigm which is much more comfortable to the Peter Schwartz I know. Which is that what we ought to be setting up is a-- what we ought to have the government do, is establish the limits. The pollution limits.
We ought to be having governments say, Look! Even as we've done with other major pollutants, we're going to limit the amount of greenhouse gases that get emitted, and then we're going to let the winners and losers emerge on the merits depending on what the least costly ways are of achieving that objective. That is an approach we have pursued in other contexts, I would submit it's the approach we should pursue here, and I want to give you my reasons for thinking that if we do, nuclear is unlikely to be among the winners.
Now first of all again, I hope this is a kind of disarmingly reasonable proposition. If you take this stuff

seriously the answer surely isn't "have the government decide what technologies to deploy," which hasn't worked tremendously well in many sectors. I would say let the government do what it does best, which is set reasonable regulatory constraints and limits and let the entrepreneurial genius the Peter Schwartz exemplifies as well as anybody I know figure out what to do.

Now if you do that, here's why I'm skeptical that nuclear emerges among the winners. I'm going to wish away several problems. I'm going to assume that there are no operational safety issues. I'm going to assume that there are no problems associated with potential terrorist attacks or sabotage on relatively vulnerable spent fuel pools, although I worry as many of you do that that's certainly a temptation out there that gets bigger as you have more and more reactors, but remember, Peter has directed you to imagine a better reactor. So that's fine. I'm going to wish that away too. I still think we end up with three big problems. As we envision a very substantial expansion of nuclear.

The first is that in order to get to Peter's world of better reactors, you somehow got to get the existing world with existing reactors: you've got to get it past the waste problem. And the waste proposition really has proved-- in 1984, the United States Congress passed legislation to force the state of Nevada to accept nuclear waste by the year 1998, which seemed like a straightforward proposition, it's a small state, relatively powerless, all the rest of us want to do this, there's 14 years, let's get this done for heaven's sake and move on, it's 2006, we are nowhere close to doing that.

Now, I think Peter is right to say let's change the value proposition here, instead of getting highly toxic waste for several hundred thousand years, instead you'll be accepting waste for a mere century or so in large concrete casks. But even Peter Schwartz is going to have a tough time selling that to the skeptical jurisdictions that are going to believe in their heart of hearts that maybe just maybe nobody's going to want those casks after the first century and they're going to be stuck with them indefinitely, or as is the case with the existing reactors, maybe the waste just stays on the existing sites and piles up. I don't think this is the worst problem that nuclear power has, but it's a formidable political challenge that nobody's figured out how to overcome.

But let's assume Peter overcomes it. And we deal with that, and Yucca Mountain fills to the brim with the wastes of the existing reactors and everybody forgets about this issue and we go forward. It still seems to me that there are two formidable problems, and I was trying to begin to tease them out as we were talking together. The first has to do with this issue of the linkage between nuclear power and nuclear bombs. Which is impossible for any of us to escape, since any of us who was watching the daily coverage of events in Iran and North Korea can see it. Iran and North Korea's fundamental argument to the rest of the world is, "Weapons? We're just building nuclear reactors just like the United States, this is civilian power. What's the problem, we're just
doing what all the rest of you are doing."

And the problem, of course, as everybody who is involved in this recognizes, is the deceptive ease with which those civilian programs become cover for illicit activity, very hard to police, there's no question I think, that we'd have a safer world in terms of long-term nuclear proliferation issues if there were no civilian nuclear industries for the weapons masters to hide behind. And one of the reasons to look forward to a nuclear free era, if we can get to it, is that civilian cover will be gone.

But here's the final reason why I think-- and the most important, why I doubt that nuclear will figure in your future. And it has to do with the fundamental self confidence that I want all of you to feel about the competition that I suspect many of you value above the nuclear option in terms of where you want to see the world's energy future go. The energy efficiency options, I mean to have energy efficiency and renewable energy appear as two items on a list, is for any of you who know the diversity of these technologies and options of course very misleading and constraining. We're talking about literally

thousands of options. We're talking about the ability to create portfolios, combine both out of efficiency, a whole host of renewable electric generation, the biofuels options that we haven't even started to talk about yet this evening, all I am seeking in my advocacy and what I'm trying to accomplish, is an equal opportunity for them to compete against
the nuclear plants and the other options.
I am a little bit amused when the issue arises, should nuclear power be on the table or not. Nuclear power's been on the table for my entire life. Which would span most of the life cycle. It's never been off the table. It has an army of lobbyists in Washington, with funding at least a hundred times those of every anti nuclear activist in the country, it has a hundred plus operating reactors in the US, each with a thousand plus employees. It has university centers across the country, it has a whole army of committee chairs and the congress supporting it aggressively, it has complete protection, or largely complete protection against accident liability, it has subsidies for licensing, subsidies for citing, operating subsidies, loan guarantees for the next generation of plants, I think Peter would be hard pressed to think of anything else one could do right now to put nuclear even more firmly on the table. And yet. This is the extraordinary thing. Not one nuclear plant has been ordered and completed since 1973. I suspect that before the births of many in this room. And that is because at least in this country nuclear has time and time again failed fundamental competitive tests, and this is I think the fundamental reason for my confidence that better options will prevail, is that I expect the future to be a reprise of those competitive tests. Now the competitive tests in the future, I think Peter's right, they'll be carbon constrained. That is, you'll get points if you have low, relatively low, carbon dioxide emissions, and nuclear will get some points. Nuclear's been getting points all its life. It still can't win. Giving it a few more is unlikely to change the outcome, particularly since the same kinds of options, the same-- I mean options with equally appealing low carbon characteristics, will be getting the same benefit in those competitive contexts.
So what you're going to see, and you'll see it first in California, as California moves as it already has, toward constraints on carbon emissions the governor has set, progressive targets to reduce carbon dioxide emissions, I know Peter and I celebrate that first move, now he's got to act on it, likeliest way he acts on it is, and it's already starting to happen, is you begin to put your thumb on the scale. You begin to say, we want to develop our electric options with an eye toward minimizing carbon emissions. Today, in a historic moment, which I suspect not many of you have heard about yet, so I want to make sure you're aware of it, California PUC has proposed to limit the total carbon emissions associated with the resource purchases of the state's major utilities. And that process as it gets underway, and yes, absolutely...that's worth a moment.
I'm going to commemorate something else in just a moment when I close that's even more important, but what that reminds us is that we are moving into a carbon constraint era, but think about what that has meant in recent years for California. We've already started to do it. Did you know, for example, that when California utilities evaluate energy efficiency against renewables, against coal, against nuclear, they're required to assign a penalty, a cost penalty, to resources that emit carbon dioxide. So nuclear's already getting a thumb on the scale among California. Hasn't made a noticeable difference yet. What has happened is that we've launched the world's largest energy
efficiency and renewable energy investment programs.
And that is, frankly what I think, here's where I sometimes get into trouble, but I want to bring you this far with me. I think Peter's right on one point. I think nuclear gets to compete. I don't think we can say, "We want low carbon options, we want a fair-- we want to go after all the cost effective efficiency, all the renewables, and we're just going to rule nuclear out of that competition, they can't possibly make

a showing, it makes us sound like we're scared of the nuclear option. It makes it sound like we think maybe there's something good out there that might beat our stuff, so we want to keep it away. We want to rule it out. We shouldn't be doing that. We should be saying and meaning, we can take them on and beat them just as we've taken them on and beaten them for the last 30 years straight, often in situations, if you think about the remarkable fact of no orders since 1973.

We're not just talking about no orders in California, we're talking about the whole country, we're talking about the southeast, we're talking about some places while in ideological terms at least are quite different from the audience spread out in front of me this evening. And you know, the most important reason for that, in the years since 1973, more than a hundred nuclear reactors were cancelled, many in an advanced state of construction, not because protesters went after them but because the costs spiralled out of control, and the utilities that sponsored those plants had to eat about 60 billion dollars, most of which they weren't allowed to pass on to customers. That creates vivid and enduring memories.

And so somehow you have the interesting challenge in the United States if you want a nuclear revival, in addition to everything else, you've got to overcome that rather vivid and eloquent history. And what I would want to say to all of you is that I see no evidence at this point that the nuclear plants can do it.

Now what Peter's telling you is imagine a better nuclear plant. And the difficulty in imagining a better nuclear plant is they will have to-- that means the whole-- the existing infrastructure's not going to be terribly helpful, we're going to be moving into something completely different, the first few are going to cost a lot more, they're going to create some significant financial risk, the utilities that are being asked to take on that risk will be wanting lots of help from the taxpayers of the United States, and this is a message I'll keep coming back with you on, the resources of the United States right now, the public resources, are constrained.

There is a limited amount available for public subsidy of any resource, and the notion that somehow there's going to be a willingness to make the public investment necessary to create resources of this scale, and remember this is the fundamental problem of a nuclear plant. Think of how big they are. Think of how long they take to build. Think of how much of a system's capitol and operating capacity they take up. And they're surrounded by smaller and nimbler competitors. The efficiency option, the renewable options.

To bring this home to you, I wanted to close with a hometown example. For nuclear activists over the last quarter century, the institution you most love to hate, at least if you went back to 1979, was the bad ol Pacific Gas & Electric Company. The Erin Brokovich utility, the people who couldn't shoot straight, the Diablo Canyon blueprint switchers...today, today, your hometown utility, Pacific Gas & Electric Company, is the largest investor in energy efficiency in the world. It will shortly be very likely the largest investor in renewable energy.

And it's a result of the actions on solar this week, which many of you contributed to, the largest investor in solar. It's running a resource procurement program, it's acutely conscious of carbon risk, and by the way, if you look at the future that PG&E is now charting, it's not-- there's no nuclear and there's no coal in it of course either. What they're trying to do is build a future around efficient use of waste heat in natural gas applications, they're trying to add a lot more renewables and they're trying to do more energy efficiency than any other utility in the world has ever done, and I would submit to all of you that that's the model.

And what I want to close on is there is someone here in this room who helped start that revolution at PG&E, and it's Carl Weinberg who's sitting right there, as the former head of RND and it's his birthday tonight! And I would appreciate it if you would all let him know that you appreciate it! And so I want you to take away from these remarks not a sense of a relentless attack on a particular technology, but a

sense of boundless enthusiasm and optimism about its competitors, and the hope that all of us together will watch the most effect international demonstration that those competitors can and will prevail over the long term right here in California. Thank you.
Very timely, Ralph. Right on time. Peter?
Well done. We don't need to spend obviously any time on the question of defining the problem. I think we both, as you said, you accept my definition and I don't think you changed it in any way significant. I want to explore a few issues that you put forward. First of all, the issue of nuclear waste. Okay? You've characterized the picture of Yucca Mountain filling to the brim, etc etc. When you think about today's waste problem, let alone the future, we have one today, especially military waste and so on. Do you have something in mind? Do you have a vision of how we will deal? Even if we didn't go any further with nuclear, how we'll deal with the realities that we already face?
As a practical matter, what I expect us to do, and I'm not happy about it, but I think it's the only practical option available, we'll entomb the wastes on the sites where they now are, power plants where they now exist, in formidable concrete casks, which you described, actually in your remarks. Which I agree is the best interim solution I can think of. And Peter, if it were up to me, I wouldn't have launched all of this without a clear sense of what I was going to do with the waste, at the end.
But here we are.
But here we are, so I think what we need to do now is concentrate on safer storage on site, and also on doing a better job of protecting the relatively vulnerable and
exposed pools where a lot of the depleted fuel now sits.
Then what.
Then it goes into the casks, Peter, and then ultimately-- and then what happens after that, my hope obvoiusly, is that after about a century, here I think I share your sense of technological optimism, we have a better sense of what to do with it, than simply entombing it in Yucca Mountain. And sadly, I think that's the best we can do. At the moment. That is, my strong preference would be, and I think a lifetime of advocacy allows me to say this, my strong preference would be that we had not begun this adventure. But now that we're here, I think that what we absolutely must do is take more seriously the risks associated with that waste on site, the potential temptation it provides for people who don't wish us well, and we need to do a better job, and I think this is an urgent
national priority for the regulators, of protecting that stuff.
Let's move onto one of the other issues which you obviously got into, which is the issue of proliferation.
Yeah.
So today there are nuclear fuels moving around the world, there are countries building reactors, there are countries who want to pursue the technology. China is probably the country where they're building the most nuclear power plants at the moment, and expecting at least thirty or so. In light of the fact that there is movement, already, toward further nuclear power around the world, toward issues associated with proliferation, because not all of those countries are either stable or friendly,
Right.
How do we deal with the current realities of proliferation, because it's already an issue.
There is no question that we ought to do something that I think this administration has conspicuously failed to do, which is to support and strengthen the international safeguards associated with the International Atomic Energy Agency. And-- yes, absol-- and sadly we've kind of developed a national contempt in some quarters for international institutions, this is one place where we desperately need them. I know everyone in this audience was as delighted as you and I were that the agency actually got the Nobel Peace Prize this year. So that's certainly critical.

But Peter, I don't take it for granted-- I think the question of how much expansion there will be of worldwide nuclear is still very much an open question and depends a lot on what we do. Nuclear power's actually lost market share over the last decade, in the sense that yes, some reactors have continued to get built, but the growth in reactors has lagged way behind the growth in electricity use. So at the moment, nuclear power is a declining asset worldwide. There are a handful of centrally driven economies, the anathema of everything Peter Schwartz ever taught me, where it's still alive and relatively well. But it's not flourishing at the moment.

Okay, let's move on to the alternatives. Yeah. You made the observation that there are thousands of options.

Right.

And so we see here in California, one of the great success stories, wind, we've seen efficiency, but what about the other renewables. What do you see for the fate of things like solar electric, are they going to need the kind of subsidies that we are getting forever.

Well no I think no technology is well served by being subsidized forever, and I think the California PUC in the last week did exactly the right thing with its solar program, which is to create a ten year system of steadily declining subsidies, on a known trajectory, so the industry either stands on its own at the end or fails and there's constant pressure to reduce costs. And I think that's a good-- and the payments are based on performance, not on how much it cost the suffering home owner to put the system in. So you've got a completely new paradigm for solar in California now. And it's an exciting one, and I hope many in this audience will take advantage of it.

But Peter, I think the option, the other option I would encourage you to look at more closely, because you are getting very much locked into a paradigm where electricity has to pick up all of the slack on the transportation side. It seems to me at least possible that bio fuels can do a lot of this. Not the bio fuels of our traditional corn-based systems, but a very significant shift toward what is called cellulostic ethanol, where you're using the whole plant where you can use agricultural wastes, and where you have a chance to add a very interesting new option to a low-carbon future.

And what's the economics of cellulostic today?

Well I think there it's very, what you say very much the same thing you're saying about imagine a new reactor. We don't know yet. And so what I hope we will do is give it a competitive opportunity, and set up, and basically set up-- what we, if you look at what the PUC has done, what the energy commission, the basic California approach to pushing all of this stuff, is you set up a limited amount of subsidy. You make everybody who meets an environmental performance criterion compete for that subsidy. And you base the winners of those who can deliver value for the least amount of subsidy. That's a good approach. We're not locking in big chunks of money for somebody, regardless of how well they do, which heaven knows was the nuclear approach for too long. We're basically saying, it's a performance based system, it rewards those who can deliver the most at the least cost. That's the way I'd like to see us go and we are going. On both renewables and efficiency in California.

So when you try to balance all of these things. The risks of climate change. The risks of rising energy demand if we don't achieve huge gains and efficiencies. Particularly taking into account China and India and so on. The risks associated with technological failures and success, we've talked about a variety of technologies. Nuclear, wind, solar, cellulocity, bio fuels, efficiency, so on. They all have technological risks associated with it. Do you judge the risks of one a priori as greater than the other and therefore we should bias the system?

The most important thing for me is I don't want to pick the winners and losers, and I don't want the government to pick the-- I want the government to set up a system that basically establishes what the

pollution control rules are. And then I want to allow for a fair competition. Where you can actually let these options, many of them which are not yet matured, fight it out, Peter. And what I hope we will not do is say, There has to be a nuclear wedge of this size in order to solve the problem. What I hope we will do is to say, This is what it will take to solve the problem.
These are-- the thing we most urgently need now, is we need the Congress of the United States, or failing that, a significant group of states, to establish binding limits on carbon dioxide emissions. That are known over time, over an extended period, and that begin to drive technology toward a low-carbon direction at the lowest possible cost. And I hope all of us, all of us, could unite in supporting that. The good news, guys, is that the Congress, this past summer, for the first time, the majority of the Senate went on record in support of mandatory limits on carbon dioxide emissions. And that was the same Senate, remember, that seven years earlier had voted 96 to nothing against ever doing anything like that for all time. That's a significant shift. We should capitalize on it.
Okay. Ah...you talked about making it a fair competition. But obviously the government determines a variety of things. For example, the criterion. I.e., which pollutants? CO2 has been one of the big issues. Government funds RND. The nuclear budget went pretty close to zero as the renewables went up. What role for the government in all this?
Well I do think it's fine to have a government RND budget, Peter, and actually my gentle disagreement with you-- nuclear never went anywhere near as close to zero...for me, I think it never got below a hundred million, and it's now up above 200 million, and again the total nuclear subsidies for the past 50 years, conservative estimate, 150 billion. There is an argument to be made that we've done enough RND on this particular technology. But I think it's fine for the government to try to help. There's so little private RND on energy, and so little technology development. If you look at the combined public and private investment in creating better technology in the United States over the last quarter century, down about 75% when you adjust for inflation. We clearly need to do more of that.
And I would not personally object to seeing more of that go into the possibility, at least, of better reactors, better fuel disposal, safer operation, since we have a hundred reactors right now, we've got communities around them, we've got a stake in making sure that they ramp down in a reasonable and prudent way. What I don't like to see is the government then ste-- I mean, what I think the error of the energy bill was to go beyond that and really begin to add a whole new set of subsidies for operating reactors. Again, fifty years into the development of the technology, when there's a real risk, Peter, that that money won't go to the exciting new technologies you're envisioning, but just one more round of the old stuff that frankly hasn't been remotely competitive every time there's been a test.
I think we're wrapped on that part. Peter, it's time for you to argue Ralph's case.
Okay. Well, I think the brilliance of, you know, it's really a daunting experience to debate Ralph Cavanagh, we say this...I think my colleague and friend over here put forward I think very eloquently. The problem is clear, we all see the problem of radically reducing CO2. I don't think that there's any doubt about the need to do that. The question is, how do you make the choice among the options? And I think Ralph is arguing that the system has been biased toward nuclear and away from other options, with important exceptions, like California, where we've run the experiment of what happens when you mostly begin to get it right? Where you begin to make a lot of the choices about efficiency right? You begin to create the room for new options to develop, new technologies to come to market in California, as a very good example of having done it right.
And that in fact I think Ralph has an enormous amount of confidence in the choices that we would make if we were really exposed to the realistic costs and risks, and if those were evident in the marketplace, and if all the options really lowered their full costs as it were, that the more benign

options, like solar and wind and efficiency would tend to win far more often, and that if nuclear actually achieved similar levels of performance, why it could compete and win as well, and Ralph would have no objection to it if it were meeting the same kinds of criteria that in fact all the other sources, including efficiency among them, also had to meet.
All of that is true, except that Ralph is profoundly skeptical that that could ever occur. But that is in fact very fair and appropriate. Thank you.