

**Yale Climate & Energy Institute Conference: The Future of Nuclear Energy**  
<http://www.yale.edu/ycei/futureofnuclear/>

**Panel 1: Overcoming Barriers to a Nuclear Renaissance: Safety, Waste, and New Technology**

**Opening Remarks**

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As an academic trained in the field of nuclear engineering, it is difficult to have credibility in the face of nuclear energy skeptics that I am in fact a skeptic myself. And the skeptics are right to some degree, because my training has given me a certain degree of trust in the nuclear energy community, and with that comes some subjectivity. Nevertheless, I think that nuclear energy, and all other technologies should be viewed (1) critically - we should continuously ask - what kind of a nuclear renaissance do we want? do we want a nuclear renaissance? why? and - VERY IMPORTANTLY - (2) technologies should be viewed in context.

(2) What I mean by context has to do with the fact that risk is relative. There are 30 thousand car crash fatalities a year in the US (that's about 3 times the population of the Yale campus), and yet we don't stop driving. Because it's necessary. Or to be more specific because we consider transportation an important benefit and we don't have other alternatives. It makes no sense to take a risk without a benefit, no matter how small that risk is. And it makes no sense to take a bigger risk when lower risk alternatives exists, For nuclear energy, the benefit is energy, and the risks and costs fall in many categories (1) safety, (2) environmental protection, (3) social responsibility for the management of spent fuel, (4) non-proliferation, (5) national security, (6) international security and so on. So let's take these risks and compare them with the energy alternatives: spent fuel management for fossil fuel - the CO2 goes up the stack, prompt and latent mortality due to the coal industry. [show slide - mortality metric] On some of these criteria we can make simple judgements, but on some we cannot. We cannot simply sum up the risks from each energy alternative in one single dollar-value comparison, or into a fatality count as the ultimate metric. Nuclear energy HAS A COMPLEX CONTEXT and this is why we have panel discussions as the one the we have today.

In addition to nuclear technology being a topic with a very complex context, there are two other features that are unique to nuclear, and make the conversation even more difficult: (1) SPACE and (2) TIME.

(1) I choose to take the risk of driving a car, and I directly and immediately benefit from this risk. I also feel empowered to reduce my risk - I buy a safer car, I drive cautiously, I go to the gym to make up for the time that my metabolism suffers from being inactive in a seat for too long, and on a routine basis I forget about the impact of air quality on the houses along the freeways or on the health of the bike-riders. So I directly see the benefit, and for one reason or another I accept the risks, so I feel that I have a choice.

With electricity however, I don't have an individual choice. It's a societal choice. I can't choose to connect to a nuclear plant, while my neighbor connects to a wind farm, and even if I can, the risks of the nuclear plant still extend to my neighbor. So now instead of trusting myself, I need to trust society. And this makes the conversation complex.

(2) In addition to the complex context, and the distribution of risks and benefits over large populations, there is another factor that we need to detangle well in conversations about nuclear, and that is TIME. When we evaluate the many dimensions of nuclear power we need to clearly define the TIME HORIZON. spent fuel is a challenge - FOR WHICH GENERATION? - today it's an economic challenge, or, light of the lessons learned post-Fukushima, a safety concern - in the distant future it may become an

environmental concern. when should this issue be addressed? with timescales of decades, technologies and costs evolve significantly, so the questions of HOW and AT WHAT COST and COMPARED TO WHAT ALTERNATIVES have to always come hand in hand with the question of WHEN.

Lastly, I will mention that my research is in the area of advanced reactors, specifically salt-cooled high temperature reactors [show slide - FHR] that can run high efficiency open-air cycle gas turbines [show slide - turbine] that have the capability for power peaking. So in my subjective vision of a nuclear renaissance, we will build a global fleet of such reactors over the next couple of decades, motivated by economics and an urgency to address carbon emission and growing global energy demands. While we do so, we'll very diligently work on improving safety, because it goes hand in hand with economics. All of the nuclear industry should be regulated to the same safety standards - the inherent safety features of salt-cooled reactors make it easier to achieve these standards with simpler and hence cheaper approaches. We also very diligently work on improved fuel utilization and hence reducing the amount of spent fuel. This doesn't mean that we're putting spent fuel disposal on the back-burner, it just means that we're first addressing the pressing issue of climate change and creating a profitable nuclear industry that can then reinvest in spent fuel management, non-proliferation, safety and security in the subsequent decades.

So I think of all of the complexities of new nuclear technology, and I focus on one dimension - economically competitive energy production that can displace fossil fuel, because improving one is better than improving none. I also think of the several time horizons, and I focus on a successful present that also supports a successful future.

I'll leave you now with a quote by the poet Gertrude Stein, which I often use when I talk about analysis of complex systems. [show slide - Stein] Interestingly enough, the piece from which this quote was taken was first published in the Yale Poetry Review in 1947. The title of her poem is reflection on the atomic bomb, and in its conclusion she says.... ***"Everybody gets so much information all day long that they lose their common sense. They listen so much that they forget to be natural."***

## **Panelists**

Mr. Jim Brennan – Westinghouse

Dr. Mark Peters – Argonne National Laboratory

Professor Rod Ewing – Stanford University\

## **Seed Questions for Panel Discussion**

### **Defining “renaissance”**

1. What is a nuclear renaissance, and what timeline does such a renaissance have?
2. What are the drivers for a nuclear renaissance globally and nationally, and how are these different from 40 years ago when so many plants were built? And from 20 years ago when very few plants were being built?
3. If a nuclear renaissance is premature today, what might the drivers look like for a nuclear renaissance 10 or 20 years from now?

### **Discussing “challenges”**

1. Economics: why is it difficult to predict - what are the key risks? Existing plants vs new LWR plants vs. advanced plants. US vs. global.
2. Safety: Is safety a challenge or an opportunity? Existing plants vs. new builds.
3. Innovation: Is there sufficient innovation in nuclear energy? In what form do we see innovation in the nuclear industry today?
4. Spent fuel: How do we decide how urgent it is to address the spent fuel problem - economics, nonproliferation, security, safety, environmental protection, responsibility towards future generations, legal obligations? How different are the solutions if we look at different time horizons?
5. Non-proliferation: would non-proliferation and nuclear security face new challenges or be helped by a global nuclear renaissance?

### **Concluding remarks - final question**

1. We have an audience of future and current policy analysts, entrepreneurs, business leaders, engineers, scientists, inventors, researchers and educators. What are the actions that our audience can take to shape the direction of the nuclear renaissance that we see on the horizon?

### **Other potential questions**

1. Spent fuel, and the connection to non-proliferation and arms reduction.
2. Lessons from Fukushima