The Science (and Art) of Science Communication for Nuclear Technology: A Matter of Perspective

Address at

The Arthur M. Sackler Colloquia on “The Science of Science Communications,”

The National Academy of Sciences, Washington, D.C.

on

May 21, 2012

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Thank you for the opportunity to speak today at the Sackler Colloquia on “The Science of Science Communications, here in Washington. I want to thank Barbara Kline Pope for inviting me to be with you to share my perspective on communications of Nuclear Fission Technology.

The inspiration for this address came from Mark Reed, a graduate student at MIT whom I met at an American Nuclear Society conference last month. He gave a presentation entitled “Creative Writing on the History of Nuclear Technology.” In that presentation, he discussed a series of articles he wrote for Fortnight Journal (http://fortnightjournal.com/), an online magazine documenting the promise of the millennial generation, “the last generation to remember a time without the internet.” When he finished, I asked if he would collaborate with me. This is the result of that effort.

Almost two billion years ago, nature started fission in a subterranean uranium deposit in what is now Gabon, Africa. However, it was scarcely more than seven decades ago (1938, to be specific) that Lise Meitner reproduced this phenomenon in a lab.

Just five years later, beneath some old bleachers in Chicago, a few of our finest physicists piled up some blocks of uranium and graphite and brought nuclear fission technology into the world. They changed society forever. Now, whether we like it or not, their innovation is here to stay. We brought it from rumor to reality, and we can't turn it back.

Its introduction was abrupt and violent. Few technologies have progressed from scientific discovery to practical application in as short a time as nuclear fission. Less than eight years after the discovery of fission, President Truman ordered the atomic bomb dropped on Hiroshima. The war was won, and a new era was born.

We conceived nuclear fission technology, and in a time of great desperation, we used it for destruction. The scientists who invented it foresaw its potential to dehumanize, but those same scientists also foresaw its potential to benefit humanity. They sought to redeem what they had created. The power of nuclear fission had already been unleashed for war - now the challenge was to harness it for peace.

The world's first man-made nuclear reactor was the Chicago Pile – Enrico Fermi's crude heap of uranium and graphite blocks. Subsequently, the Manhattan Project covertly constructed the world's first full-scale reactor in the deserts of eastern Washington State. Its purpose was to produce plutonium for the bombs. The dream, however, was to eventually build nuclear power reactors to produce commercial electricity.

Like most dreams, realization would require a single person with conviction, vision, and drive. That person was Admiral Hyman G. Rickover. He served on submarines in the 1930s, and commanded a minesweeper before the attack on Pearl Harbor. During the war, he served at, then headed, the Electrical Section in the Bureau of Ships in Washington, D.C. Rickover was a dynamo, but he was not popular.

> *"Sharp-tongued Hyman Rickover spurred his men to exhaustion, ripped through red tape, drove contractors into rages. He went on making enemies, but by the end of the war he had won the rank of captain. He had also won a reputation as a man who gets things done."* (The Man in Tempo 3". *Time*. 1954-01-11. ISSN 0040-718X.)

When assigned the task of discerning how to power submarines with nuclear energy, he had a blank slate. He went to that slate with many design options, settling on uranium ceramic fuel with two different types of coolant: water and sodium. Water won, and this basic design became the basis for 80% of all commercial nuclear plants operating worldwide today. This water reactor was not only superb for naval vessels - it was also amphibious. Four years after the first nuclear submarine USS Nautilus (SSN-571) got "underway on nuclear power," Rickover oversaw completion of a land-based light water reactor – the Shippingport Atomic Power Station in western Pennsylvania. President Eisenhower's 1953 policy vision of "Atoms for Peace" came to fruition in 1961 when the Shippingport was connected to the electric grid, making it the world's first full-scale atomic electric power plant devoted exclusively to peacetime uses. Also in the same year, in Illinois, Dresden went on line with a boiling water nuclear reactor, the first privately financed, full-scale nuclear reactor. The communication of a new science, Rickover, and U.S. policy focused in the Congressional Joint Committee on Atomic Energy, with U.S. industry had completed nuclear fission technology's transition from idea to commercial operation.

From one angle, nuclear fission technology is a weapon against mankind – from another, a benefit to advance mankind in many ways.

It's a matter of perspective.

This juxtaposition of weapons against clean energy is not the only dichotomy in nuclear fission technology; for example, consider nuclear waste.

When an atom fissions, it splits into two smaller atoms and emits a few neutrons. These two atoms are not the same two every time – there are many hundreds of plausible pairs, although some are much more likely than others. We call these atoms "fission products". Having been produced out of a chaotic churning mass of protons and neutrons, these fission products are unstable and, yes, radioactive. They successively morph into other more stable atoms, and the result is a fairly large portion of the whole periodic table all mixed together in one hot stew.

This stew comprises the most radioactive component of "nuclear waste." It remains hot for hundreds of years and lukewarm for hundreds of thousands of years. The questionable screed that radiation from this waste causes cancer is the sole reason why people fear and oppose nuclear energy. It's the sole motivation behind the thirty-year bickering over Yucca Mountain.

However, "nuclear waste" - actually a potential energy resource when recycled in different types of reactors, doesn't fully deserve its grim public image. It's a vexing problem, but seldom discussed are its redeeming qualities.

Fortuitously, some of these radioactive fission products created in nuclear reactors, which would otherwise be deemed "waste," are ideally suited for medical applications. These "medical isotopes", the most prevalent medical isotope is technetium-99m, is usually produced as a secondary fission product. Every year, over thirty million medical procedures worldwide rely on it. Technetium-99m and other medical isotopes have revolutionized the fields of medical imaging and cancer treatment.

If we weren't putting these wonders into our bodies to save our lives, we would be demonizing them as "nuclear waste" and spending billions to keep them as far away from us as possible.

Some say that nuclear waste is the bane of nuclear technology. That argument is certainly not without merit – nuclear waste is a hazard, and its public policy is a perennial political quagmire. That said, to simply label radiation as a plague would be to overlook its curative applications.

Every technology has weaknesses, but sometimes, when viewed through innovative eyes, those weaknesses reveal themselves as strengths. Nuclear waste's grim public image belies the reality that it saves more lives than it destroys.

It's a matter of perspective.

By the mid 1970's, nuclear energy in the United States had reached its zenith. Over one hundred reactors were either operating or under construction. Nearly all of these were water-cooled, either pressurized water reactors (PWRs) or boiling water reactors (BWRs).

Concurrent to, or rather countercurrent to, this rise of nuclear energy was the rise of opposition to it. The modern environmentalist movement blossomed, and one of its chief aims was opposition to nuclear energy based on radiation health risks and reactor safety. Consumer activist Ralph Nader was the titular head of the U.S. anti-nuclear movement, and he garnered national attention for his efforts.

Hollywood didn't wait long to help in the communications of nuclear science releasing "The China Syndrome," in 1979. "China syndrome" is jargon for a preposterously fictional severe nuclear reactor accident in which the entire core melts through the reactor vessel and into the earth's crust, even all the way to China (by defying the laws of gravity). In the film, a news reporter (Jane Fonda) and her cameraman (Michael Douglas) inadvertently discover that a reactor is actually unsafe and that its construction company falsified regulatory documents. The cameraman attempts to uncover this, but company goons attempt to silence him in an absurdly dramatic chase that culminates in a SWAT team shooting. In the film, a physicist posits that a real "China syndrome" event could render "an area the size of Pennsylvania" uninhabitable.

The China Syndrome debuted on March 16th, 1979. Twelve days later, on March 28th, the Three Mile Island melt down occurred in central Pennsylvania. No one was hurt or seriously injured, and the amount of radiation released was vanishingly small.

Unfortunately, facts and reasoning seldom move people. Instead, images move people. Beauty moves people. Ugliness moves people. Therefore, Hollywood moves people.

The political reaction generated by this purely fictional, physically impossible accident scenario was severe. The release of The China Syndrome sensationalized nuclear accidents and greatly exacerbated public reaction to the TMI accident. It was Hollywood's most famed coincidence. Six months later, its leading lady Jane Fonda held an anti-nuclear rally with

Ralph Nader in New York City that attracted about 200,000 people. Soon, public support for nuclear energy dropped off to well below 50%. Orders for new nuclear power plants and coal plants ceased as U.S. electrical growth slowed. Enrollment in nuclear engineering university programs dwindled, and an entire generation of talent was lost.

Nuclear technology didn't lose that generation due to engineering challenges – it lost that generation due to public image challenges due to our lack of developing strategies for effective and trustworthy communication with lay publics.

It was a matter of perspective.

In the 90's, new nuclear fission power was considered dead. People didn't want reactors in their backyards. Nearly the whole environmental movement was firmly opposed, and there was little political support. Why incur political liabilities to build expensive nuclear power plants when we could keep burning fossil fuels?

Then there was a paradigm shift. People realized that the earth has been warming, that the climate has been changing. A scientific theory formed that carbon emissions were a likely culprit. Although the share of man-made contribution to this remains a politically contentious issue, man's responsibility for climate change has become a central tenant for the environmentalist movement.

This ascendancy of climate change science as a salient science/political issue is helpful for nuclear energy. As the lay public grapples with the complex non-linear responses of – climate science – nuclear technology is easy. For example one member of this panel this morning, Dr. David Keith in a January 11, 2011 presentation titled; "GeoEngineering: Should We Deliberately Manipulate Global Climate" stated with clarity two facts:

> "1,000 years after emission stop, CO_2 concentrations are ~60% of their peak.
>
> 1,000 years after discharge nuclear waste is 1,000 times less radioactive that it was one year after discharge."

The simple science message: <u>CO_2 lasts longer than nuclear waste</u>.

Nuclear energy is the only source of electricity that is base load, inherently scalable, and carbon-free, three criteria necessary for a sustainable energy future. Base load energy supplies are constant in time. Solar energy, which oscillates daily with the sun and wind energy, which vacillates intermittently with the breeze cannot provide constant - base load - power supply. Tidal energy, like solar energy, is diurnal. Fossil fuels, such as coal, petroleum, and natural gas, are base load but not carbon-free – if the current theory is correct, they exacerbate climate change. Scalable energy sources can be "scaled up" or multiplied without restriction to meet any level of electricity demand. Hydroelectric and geothermal energy, although base load and nearly carbon-free, are not scalable. There are only so many suitable dam sites, and there are only so many suitable geologic "hot spots". Thus, nuclear energy stands alone as a triune of sustainability – base load, scalable, and carbon-free.

This isn't "greenwashing" – it's science that I am sure Arthur M. Sackler would appreciate. Nuclear energy isn't dirty; it's clean-air energy. Nuclear energy isn't a conservative cause; it's a bipartisan cause, even a progressive cause.

Throughout the first decade of this century, nuclear energy began to resurge in the U.S. The 2005 Energy Policy Act authorized loan guarantees for potential new plants to help offset their large capital cost. This year, two new reactors are under construction in Georgia, the first built in the U.S. in over 30 years. Two more will soon be underway in South Carolina. Enrollment in nuclear engineering university programs has dramatically increased, with over twice as many bachelor's degrees awarded nationwide in 2009 than in 2002. In the 2008 presidential election, all five major candidates who received at least 10% of votes in their party primaries – Barack Obama, Hillary Clinton, John McCain, Mitt Romney, and Mike Huckabee – at least tepidly supported a second look at nuclear energy. Around the world, 109 commercial reactors were either under construction or on order as of December 2010. These new reactors, mostly in Asia, will increase worldwide nuclear energy production by 28%.

This so-called "nuclear renaissance" is about more than the resurgence of a technology. It's about reconciliation – how an inconvenient truth drove nuclear engineers and environmentalists, once adversaries, to become allies. It's not about overcoming engineering challenges – it's about overcoming public science communication challenges.

It's a matter of perspective.

Of course, last year's events in Japan complicate the building and operating of current plants. The Fukushima crisis was severe. Yes, three reactor cores were damaged. Yes, chemical explosions from escaping hydrogen occurred. However, this was a direct consequence of a catastrophic natural disaster of historic, unprecedented, and previously unimaginable proportions. The earthquake and tsunami have utterly devastated Japan, and the magnitude of the total ruin dwarfs that of the nuclear component - as our moderator and respondent of this session Miles O'Brien, Science Correspondent PBS Newshour, explained in his FRONTLINE shows on Fukushima.

Nevertheless, as grave as these circumstances are, it is not the physical disaster that is my principal worry. I don't fear nuclear meltdowns. I don't even fear widespread contamination. The only thing I really fear, if you will accept a well-respected quote, 'is fear itself.'

You probably recognize this as a reference to Franklin Roosevelt's timeless words: "The only thing we have to fear is fear itself." The antithesis of this quote is another that has permeated U.S. political dialogue in recent years: "Never let a crisis go to waste." The implication of the latter is that for people in power, crises such as Fukushima represent rare and precious opportunities to achieve political objectives. In the wake of crises and amidst ensuing media frenzies, there is a dangerous propensity for governments to make rash decisions with respect to long-term policy. People are myopic by nature - they tend to lose sight of important long-term goals to take advantage of whatever peril looms large at the moment.

Although President Obama has displayed his characteristic calm steadiness in affirming his support for increased nuclear energy in the U.S., other nations have succumbed to transitory public fear. Germany has decided to phase out all nuclear energy. The new French government seems to want to follow suite. But, two Japanese nuclear plants are being considered for re-start.

Evidently, people saw opportunities in distorting the science story of Fukushima.

Nuclear energy is especially vulnerable to this sort of opportunism, as the word "nuclear" tends to incite an especially feverish reaction in the media as well as the general public. Hollywood-esque memes related to radioactive contamination and weapons proliferation have stoked up widespread fear of the word "nuclear." This fear, which can exist only within a void of inaccurate information, has led to a great irony: that many environmentalists — those who care most about a clean energy future — oppose nuclear energy, an essential means to achieve that future…even as they benefit from the medical, agricultural, and manufacturing applications of nuclear technology.

Every unbiased quantitative study of future U.S. energy resources has concluded that we cannot meet our carbon emissions goals without a substantial expansion of nuclear energy. The numbers just don't add up any other way. Tragically, this fear of a word, nothing more than fear itself, has made foes of should-be friends. The Fukushima event has only exacerbated this sad irony. It has strained the tenuous alliance that developed between nuclear engineers and environmentalists during the past decade. Thus, we now sit on a cusp, a tipping point. We could progress into a global realization of the "nuclear renaissance", or we could regress into a fear-driven anti-nuclear paradigm not based on science.

This, too, is a matter of perspective.

The nuclear energy issue isn't about engineering – there are no technical barriers that preclude a full-scale realization of the "nuclear renaissance." Our engineers are more than capable, more than ready. Whether we Americans reap the full benefits of nuclear energy hinges not on the viability and safety of nuclear technology, but rather on the public image of nuclear technology - the lens through which we view and assess that viability and that safety.

It’s a matter of perspective, and it’s a matter of communicating that perspective. As Arthur M. Sackler believed, science and art are inextricably linked. Effectively advocating science often requires skillful, artistic communication. Art moves people. Eloquent prose moves people – it shapes public opinion, and for nuclear energy, that’s paramount.

While the Fukushima incident has temporarily slowed the revival of nuclear energy, it will not halt it. As long as nuclear engineers continue to communicate – both scientifically and artistically – the public image of nuclear technology will weather any crisis.

If not we the scientists, then who?