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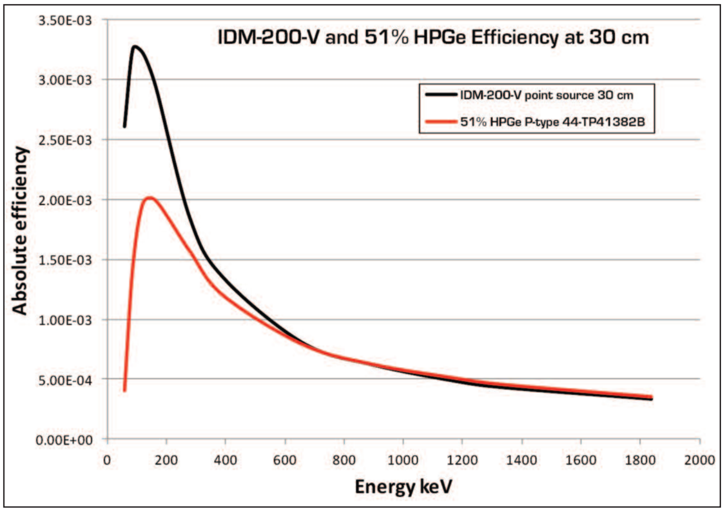

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Meeting Challenges in 2014

By Ken Sorenson
INMM President

The INMM Executive Committee (EC) met November 19-20 to discuss and approve our FY14 operating budget. Arguably, this is one of the more important EC meetings each year because the budget sets the course for planned activities throughout the year.

This is a particularly challenging year for the INMM and the EC has spent many hours developing the budget. We started discussing the budget in mid-August and held biweekly conference phone calls right up until the EC meeting. At the meeting, the EC presented the draft budget for discussion to all participants. In this column, I discuss the approved budget and its implications.

In FY13, the INMM took an overall operating loss of more than $100,000. This is even with the very successful PATRAM conference in August that prevented the loss from being more significant. The U.S. government travel restrictions, coupled with the hotel contracts for the annual meetings that we signed years in advance, were the principal reasons for the loss. Recognizing that conference attendance will probably not rebound significantly in FY14 and that INMM will not have PATRAM this year, the EC took some significant measures to develop a balanced budget. The EC addressed both the revenue and cost sides of the budget. While the most noticeable impacts will be to the Annual Meeting, changes will occur throughout the operational structure of the INMM. Let me identify some of the major changes.

Revenues

The INMM raised member dues to $60 per year from $50. This modest increase represents the first dues increase in at least thirty years. We also raised Sustaining Member dues and the Annual Meeting registration fees. While the projected increase in revenue is not enough to result in a balanced budget alone, they will support our overall goal of balancing the budget through increased revenue and cuts in budgeted costs.

The Annual Meeting and workshops are the principal ways the INMM develops operating revenues. Due to the restrictions to conference travel by the U.S. government, we are not counting on large revenues from our annual meeting and workshops. However, these activities are a principal part of the INMM mission and we will remain active in sponsoring workshops and the Annual Meeting.

Costs

Addressing our expenses is the primary way the EC balanced the FY14 budget. Large cuts have been made. However, the EC is committed to INMM remaining fully engaged, so we continue to fund activities that support our mission. Therefore, the two main cuts in the budget are:

The Sherwood Group

The Sherwood Group is INMM's management company and supports all our operations throughout the year. For FY14, INMM asked Sherwood to cut their expenses to the INMM by 20 percent. Sherwood responded in a very professional and positive way. They are partners with the INMM and expect to work through these difficult times with us as a team. Sherwood has assured INMM that we will see very little reduction in staff support as a result of these cuts.

Annual Meeting

The annual meeting is where the membership and meeting attendees will see the most changes. Among the changes:

- A reduced President's Reception on Sunday evening.
- Speakers' Breakfast is reduced.
- Elimination of the banquet. We will have the awards ceremony at the Opening Plenary Session.
- Student socials will be reduced.
- Chapter and committee lunches will be reduced.

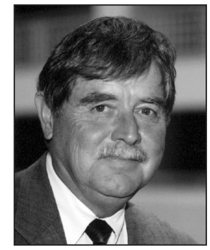
In evaluating the annual meeting, the EC concluded that areas could be cut that would not affect the technical content of the meeting. These are associated with the food and beverage costs typical of hotel events. By eliminating or reducing these events, the INMM was able to gain considerable cost-savings without cutting the core of the meeting's technical content. While these changes will be obvious to regular attendees, we trust that everyone will still have a positive experience at the annual meeting.

Conclusion

The INMM, along with many other technical societies, is facing challenging times. Historically, most of our annual operating budget revenues were generated through the Annual Meeting. With the significant drop in registrants over the past two years, we are planning for registration levels to rebound in small, incremental steps. Unfortunately, our hotel contracts were structured with the expectation that registration levels would continue to grow. This has necessitated our looking hard are this year's annual meeting expenses with resultant changes in funding the annual meeting.

Due to good stewardship of the INMM's finances for many years, we have a good financial basis and are confident that we will work through these tough financial times. The INMM's mission is more important than ever. We need to be centrally involved in the stewardship of nuclear materials in a way that is proactive, timely, and impactful. *That* is our mission. We have been very successful in the past and we will continue to be successful now and in the future.

Interesting Articles and a New Associate Editor



By Dennis Mangan
INMM Technical Editor

With this issue, we add a new topical area and welcome a new associate editor to the *JNMM* Editorial Board. Sarah Frazar, Pacific Northwest National Laboratory, is the associate editor for Education and Training. This is an expanding area for INMM as a whole, and as a result, we have seen an increase in articles submitted in this area. Coincidentally, our newest associate editor is also a co-author of an article in this issue (see below). Welcome, Sarah. We look forward to working with you.

This is the second issue that we are publishing electronically. After the publication of our last issue, the fall 2013 issue, I personally received many compliments from our readers. I certainly am excited. A side benefit for publishing our *Journal* electronically is the cost savings being realized. If you read the message from our President Ken Sorenson on the previous page, you will note that INMM has been required to be frugal with its FY14 budget. Although one of our objectives in going electronic was indeed to save money, we were obviously fortunate to get this implementation done in a timely manner.

This issue has three topical articles, all of which are interesting reading. The first is *Nuclear Energy and Public Opinion* by G. Balatsky and B. Wolko of Los Alamos National Laboratory in the United States. They do a very interesting job comparing various nuclear incidents that have occurred, and the changes in public opinion that have followed, and how such issues could impact the future of nuclear power. Their focus is not just the United States, but also has an international perspective.

The second topical paper *Beyond Human Capital Development: Balanced Safeguard Workforce Metrics and Next Generation Safeguards Workforce* is authored by four people from the U.S. Pacific Northwest National Laboratory (R. Burbank, S. Frazar, T. Gitau, and J. Shergur), one from the U.S. Department of Energy (M. Scholz), and one from the University of Washington in Seattle, Washington, USA (H. Undem). This article addresses an important issue associated with the Next Generation Safeguards Initiative (NGSI), namely, Human Capital Development (HCD), which is designed to support the recruitment, education, training, and retention of the next generation of safeguards professionals who will be called upon to fill critical positions at the International Atomic Energy Agency (IAEA) and replace a retiring workforce across the U.S. DOE Complex. The authors break the workforce into three categories: Early-Career Staff; Mid-Career Staff; and Late-Career Staff. Their safeguards workforce metrics are: Cost Effectiveness; Knowledge Transfer; and Professional Engagement. They provide a Project Optimization Model addressing the metrics and discuss several case studies. I believe their approach can be used to analyze more projects than the NGSI.

The third topical paper is *Securing China's Nuclear Power Plants* by Hui Zhang of the Harvard University in Cambridge, Massachusetts, USA. The author provides an interesting background history on the concerns faced by the Chinese in achieving the desired security for its nuclear power plants.

Our book review in this issue by our Book Review Editor Mark Maiello is on *Sanctions, Statecraft and Nuclear Proliferation,* a book edited by Professor Etel Solingen of the University of California in Irvine, California, USA. The book covers the composition of various inducements and the success and failures of the inducements in Libya, Iraq, Iran, and North Korea. Maiello concludes the strength of the book is the depth of the analyses, and offers that readers with reason to delve into a modern analysis of the effects of sanctions will find the book invaluable.

Jack Jekowski, author/editor of our *Taking the Long View* article and chair of the INMM Strategic Planning Committee, in this issue titled his column *Bumps in the Road,* reflecting on INMM President Ken Sorenson's description of the continuing effort of the Executive Committee to strategically address the various confounding circumstances that have reduced attendance at the INMM Annual Meeting due mostly to the restrictions placed on conference attendance by U.S. government agencies. He provides useful information in two areas: "INMM's Global Presence and Its Role in Enhancing International Collaborations;" and "INMM's U.S. Presence and its Role in National Standards." In addressing the first area, he provides in his article an outstanding map of the world that identifies the various locations of INMM presence. To me, this map should be of impressive significance to each INMM member or someone inquisitive about INMM's organization. It's one thing to say we're an international organization; it's another to show it.

JNMM *Technical Editor Dennis Mangan can be reached by e-mail at dennismangan@comcast.net.*

Nuclear Energy and Public Opinion

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Introduction

In today's increasingly interconnected world, the public can play a greater role in government policy decisions than ever before. This fact was recently demonstrated in the realm of nuclear energy by the 2011 Fukushima-Daichii incident in Japan. Public outreach has taken on a new importance for a number of reasons. The public can easily mobilize to demonstrate support or dissent toward a policy decision. In Japan, this has manifested itself in anger toward the agency some see as responsible, the Tokyo Electric Power Company (TEPCO), as well as toward nuclear energy in general.[1] Because mobilization can affect the re-election chances of a politician, both locally and nationally, politicians are more apt to listen to the concerns of their constituents and mirror their concerns regarding nuclear energy. Social activism, especially when news can be transmitted in real time and effectively instantly, can arouse the awareness of a greater segment of the population than previously possible. Social activism might appear most evident in anti-nuclear protests, such as when an anti-nuclear flash mob in Taiwan garnered the attention of the public and the media.[2] At the same time, it can also serve as a platform to increase understanding of nuclear energy, such as with the recent documentary film *Pandora's Promise* or through the attendance of pro-nuclear activists at nuclear hearings to ensure that both sides are represented.[3] Then, there are no longer strict borders or limits of impact. Returning to Fukushima, its effect was not merely in Japan. Repercussions were felt worldwide as international opinion of nuclear energy dipped immediately afterward. Moreover, it seems that the public does not care if the nuclear-related incident involves radioactive or nuclear materials. What matters is how it is presented to the public—and the subsequent perception—rather than how experts view it. All of these mean that maintaining public relations and outreach to the public and the press is necessary for sustainable nuclear energy efforts. Moreover, public relations and press can backfire. Presenting the wrong image or a series of conflicting reports can destroy trust between the government and the public, as can waiting too long to include the public in the decision-making process. Only a few studies have sought to determine the level of public knowledge about important aspects of nuclear energy.[4] Ultimately, it must be realized that it is necessary to include the public in decisions involving nuclear energy or risk a potential backlash.

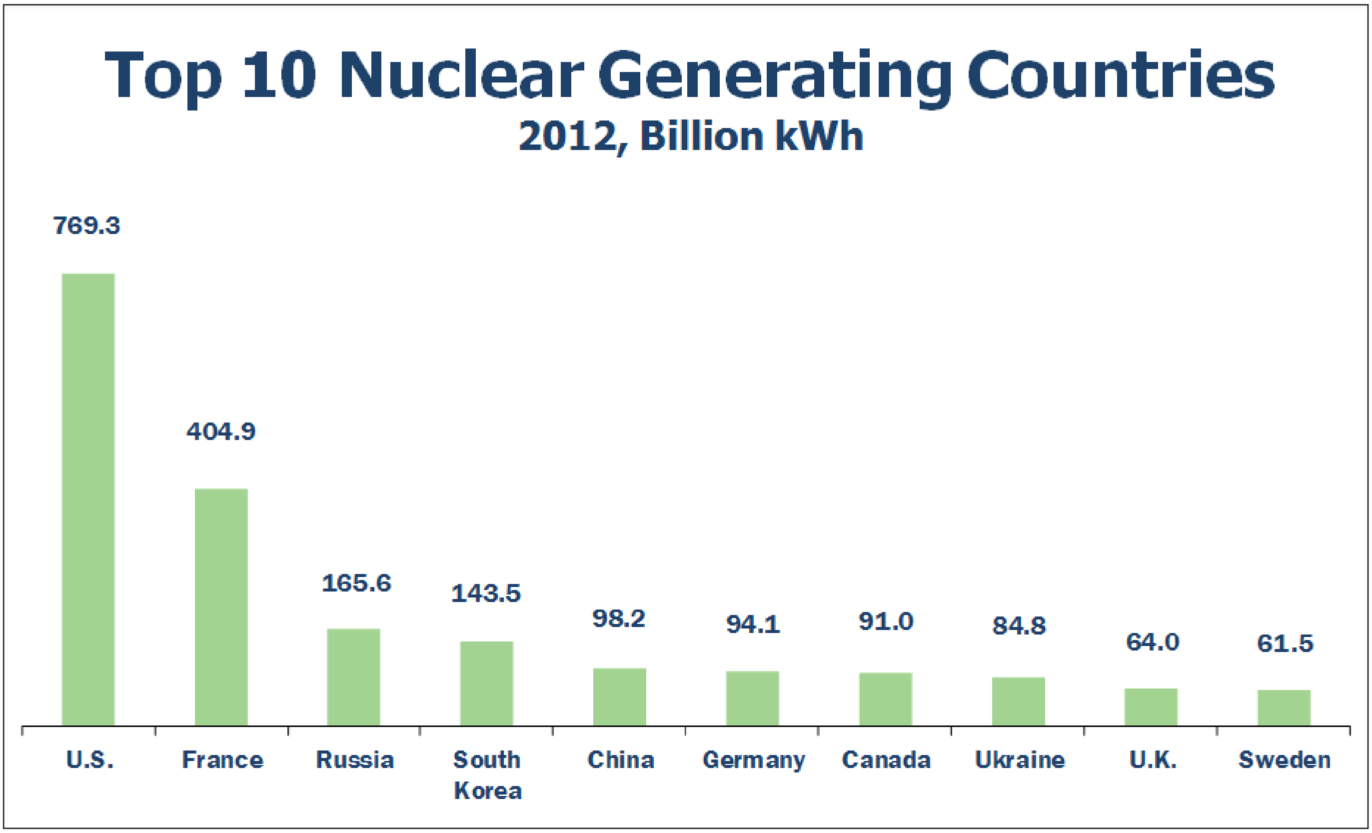
The State of Nuclear Energy

In May 2013, according to the International Atomic Energy Agency (IAEA), 436 nuclear power plants (NPPs) were in operation, producing a total output of 372,686 MWe.[5] An additional sixty-eight NPPs were under construction. Among nuclear-producing countries, the United States is by far the largest producer of electricity from nuclear energy (Figure 1). Its output of 769.3 billion kWh in 2012 was more than the next three largest producers combined: France (404.9 billion kWh), Russia (165.6 billion kWh), and South Korea (143.5 billion kWh).[6] Before Fukushima, in 2010, Japan had been the third largest nuclear energy producing country with 274 billion kWh.[7] The remaining top ten countries in output are China, Germany, Canada, Ukraine, the United Kingdom, and Sweden. However, this trend may change as other regions, namely Asia, out build North America and Western Europe. Of the sixty-eight reactors under construction, China is building twenty-eight. Russia, India, and South Korea are also all constructing more NPPs than the United States, although it will take a significant amount of time for any other country to catch up to the United States in terms of total capacity.[8] Regardless of what individual countries do, though, it should be noted that nuclear energy will most likely remain an important energy source for the foreseeable future.

The Range of Opinions and Impact of Fukushima

Although data is scarce, public opinion pre-2011 is believed to have been growing in favor of nuclear energy. In February 2006, *Elle* magazine described nuclear energy as a "cool, new thing." A 2006 survey commissioned by the IAEA of 1,800 people in eighteen countries found that a majority of participants supported existing NPPs but not the construction of new ones. Support also tended to be the strongest among people who live near an NPP, as found in a separate 2006 survey of Americans by the Nuclear Energy Institute; whereas 70 percent of those asked supported nuclear energy, 80 percent of people living within a ten-mile radius of an NPP favored it.[9] The difference could partially originate from social familiarity: those located close to an NPP can gain a familiarity with the nuclear institution through daily interaction with workers and merely the regular vision of the plant, allowing them to build a greater

Figure 1. Top 10 nuclear energy generating countries



sense of confidence in it than the ordinary citizen.[10] In a 2008 IAEA survey of Europe, 44 percent supported nuclear energy and 45 percent opposed it; the former had been growing since 2000 as support in the European Union rose.[11]

Immediately after the Fukushima-Daichii incident, public opinion shifted against nuclear energy. A poll taken right after the incident by the Ipsos Social Research Institute involving twenty-four countries, found that 62 percent opposed nuclear energy and only 38 percent approved of it.[12] Concurrently, a WIN-Gallup International poll of 34,000 people in forty-seven countries showed 49 percent globally favoring nuclear energy and 43 percent unfavorable toward nuclear energy. This is in contrast to pre-Fukushima results of 57 percent for and 32 percent against nuclear energy.[13] Finally, a Pew Research Center poll found that 53 percent were against and 39 percent supported nuclear energy.[14] Although all of these findings differ slightly, it is clear that opinion changed as a result of the incident and that afterwards, support for nuclear energy dropped to below 50 percent.

As events progressed after the incident, approval began to vary by region. Some countries, like Germany, came to reject nuclear energy outright. Others simply declined from pre-2011 approval levels. A survey of U.S. perception of nuclear energy on May 24, 2013, found that the sentiment on web news is 61 percent negative, 26 percent positive, and 13 percent neutral (Figure 2).[15] In Twitter messages, public outlook is evenly divided between positive and negative views. At the same time, the Nuclear Energy Institute has also found that more people in the United States are in favor of nuclear energy than are opposed to it.[16] While polls may tend to favor or be neutral toward nuclear power, one consistent outcome of several polls in 2012 demonstrated that the public does not want to pay for the perceived high costs of nuclear energy.[17] In 2012, the Canadian Nuclear Association found that Canadians tended to think that they knew more about nuclear energy than they actually did, and that less knowledge of nuclear and radioactive materials correlated to less support for nuclear energy. An additional finding was that a majority of those questioned believed that nuclear energy is "expensive and dangerous." Whereas 55 percent said that the word "dangerous" described nuclear energy very or extremely well and 43 percent said the same thing for "expensive," only 18 percent and 16 percent respectively said that those words did not fit it very well or at all.[18]

Yet it is important to note that the way a question is constructed can influence an answer, as can the choice of countries (e.g., Germany with developed nuclear infrastructure versus United Arab Emirates, which just started developing it) and groups polled. In a March 2012 Gallup poll, it was found that, more than other factors like ideology or education, gender leads to a difference in attitude. In the poll, 72 percent of

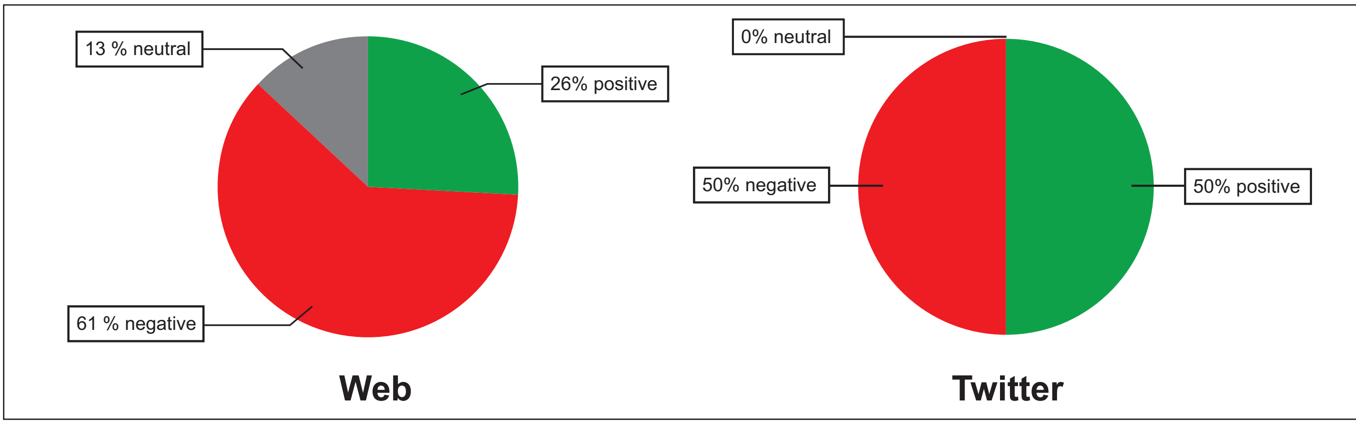


Figure 2. Perspectives on public opinion on the web (left) and on Twitter (right)

men favored nuclear energy with an equal amount saying it was safe. In contrast, 43 percent of women thought it was safe and only 42 percent favored it (Table 1).[19] At the same time, the poll found that age plays a role in approval of nuclear energy—those in the 50+ age group had a 61 percent approval rating compared to 53 percent in the 18 to 49 age group—but that views on the safety of nuclear energy were the same regardless of age, with 57 percent in both groups saying that it is safe. In another poll, by Bisconti Research for the Nuclear Energy Institute, it was found that younger ages tended to value clean air as an energy priority dealing with nuclear energy while older age groups tended to see safety as being more critical.[20] Yet to demonstrate that views are dependent on the society they are attached to, an Austrian poll in 2010 found that older age groups tended to worry more about nuclear energy risks as compared to alternate sources than younger ages did. However, the young were also largely undecided, with 24 percent of the under-25 group replying "Don't Know" to the question and only 5 percent of the over-65 group replying the same. Looking forward, it can be concluded that as the younger generations mature, they will either support nuclear energy more or will be turned away from it by events like Fukushima.[21]

Table 1. 2012 Gallup Opinion Poll March 8-11, 2012

1. Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity for the U.S.?
2. Generally speaking, do you think nuclear power plants are safe or not safe?

	Favor	Oppose	Safe	Not safe
National Adults	57	40	57	40
Men	72	27	72	28
Women	42	51	43	51
Republicans/Leaners	65	34	72	27
Democrats/Leaners	50	45	45	49
18-49	53	44	57	40
50+	61	34	57	39

It is also important to recognize other factors in the popularity or unpopularity of nuclear energy. A study by several departments from the Massachusetts Institute of Technology a year after Fukushima concluded that public opinion will undoubtedly play a role in the future of nuclear energy.[22] However, they see it only as one factor in the future development of nuclear energy, and one that did not change greatly in pre- and post-Fukushima acceptance of nuclear power. Other considerations in the study included economic, energy security, and environmental concerns. They see the future construction of NPPs being affected not as much by the public as by the economic costs of building an expensive plant in a time of cheap natural gas and heavily subsidized renewable energy, and the continued operation of old plants as being determined by the cost analysis of safety upgrades stemming from events like Fukushima versus the earnings expected for the additional ten or twenty years of operation. They predict the bulk of nuclear energy growth will be largely in the developing, non-Western world because the countries' rapidly increasing energy demands and lack of current energy security make the expensive construction of NPPs more worthwhile than it is for the developed world, which has largely level energy demands. While theirs is only one conclusion among many, the authors assert that the economics of nuclear energy largely outweigh Fukushima's impact on public opinion or nuclear energy's future.

Nonetheless, Fukushima served as a catalyst to changing policies spanning the globe. Four countries—Germany, Switzerland, Taiwan, and Italy—made the decision to abandon nuclear energy. Several other countries, at least temporarily, lost interest in attempting to build their first NPP. Segments of the public in the United States, China, France, and Belgium have all expressed reservations about nuclear energy, but in many cases reactor plans are still proceeding, with Fukushima being used as a learning experience rather than a barrier to nuclear energy.[23] Yet some countries are still actively pursuing nuclear energy, Russia, India, and South Korea included. Many others, particularly in Eastern Europe and the Middle East, have not lost their desire to develop nuclear energy.[24] According to an IAEA study of sixty-five non-nuclear countries in September 2010, fourteen of those countries "indicate[d] a strong intention to proceed" in developing nuclear power with approximately twenty others in various stages of planning.[25] In September 2012, the IAEA concluded that of those fourteen countries, only seven seemed likely to enact their goal within the short-term with the others stepping back commitment or requiring more time or finances. Among these seven, like Belarus and the United Arab Emirates, support for nuclear energy continues to remain high. In Belarus, approval of nuclear energy has increased from 28 percent in 2005 to 54 percent in 2012, with opposition being cut in half to 21 percent despite fears following Fukushima.[26] In the UAE, support for nuclear power jumped from 66 percent in 2011 to 82 percent in 2012, with main concerns centered on waste disposal rather than nuclear energy in itself.[27] The high acceptance rate in the UAE has been attributed to sustained public engagement during the planning stages.

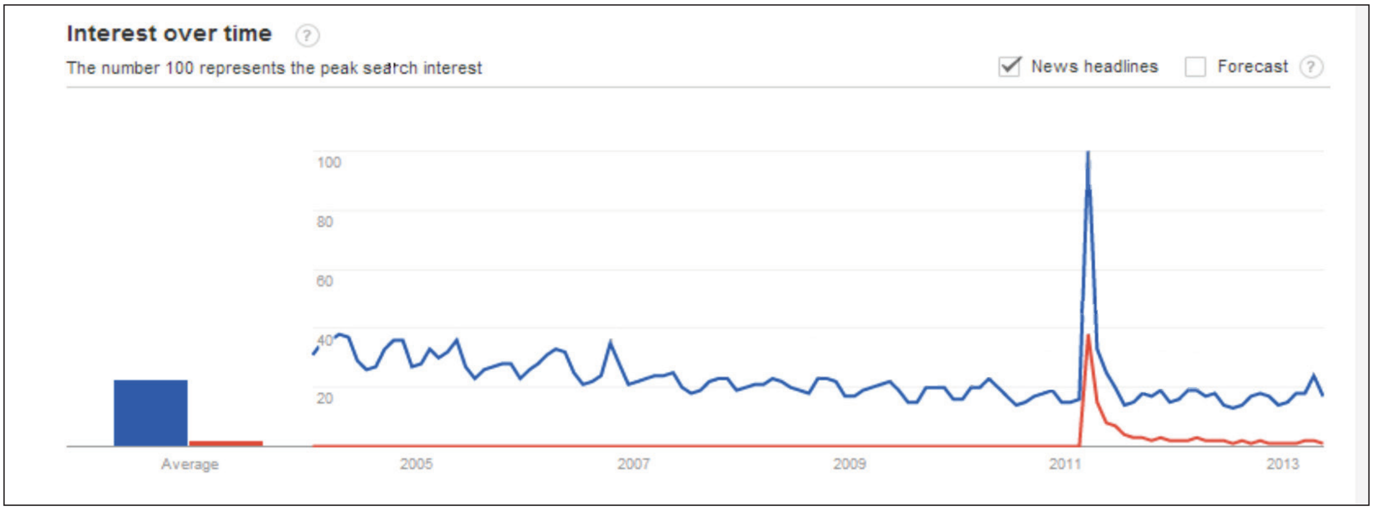
However, perhaps the most prescient case of Fukushima's impact is in Japan itself. Public backlash was swift following the incident. Authorities responsible for the nuclear industry were removed in the face of criticism for the slow and unsatisfactory handling of the crisis and its aftermath. The Nuclear Regulation Authority was created in place of the disgraced Japanese Nuclear Safety Commission and the Nuclear and Industrial Safety Agency.[28] But while the public seems to have succeeded in forcing a shift in bureaucracy, it is struggling to control the ultimate direction of policy. The government of Prime Minister Shinzo Abe, in addition to nuclear power companies and some Japanese businesses, strongly supports the restart of Japan's nuclear power plants. Of fifty commercial reactors, only two are currently running. For the utility companies, significant costs are incurred to keep the plants functional without producing output, and the government risks creating public anger if there are blackouts from an inadequate supply of energy. As a result, the government intends to begin restarting plants, with thirteen reactors anticipating on submitting a request in July 2013. According to a recent poll in June 2013 by the newspaper Asahi Shimbun of 1,871 Japanese across the country, 58 percent opposed restarting Japan's NPPs and only 28 percent supported the move.[29] In the face of this opposition, the government is even going so far as to seek to export its nuclear technology to Eastern European countries, again despite opposition of 59 percent of Japanese who disagree with using nuclear reactors to increase economic growth. While the government seems adamant on pressing forward with its pro-nuclear policies, a midlevel lawmaker in Abe's party, the Liberal Democratic Party (LDP), felt that the continued pursuit of the policy could ultimately hurt the party in the July elections for the Upper House.[30] However, in the July 2013 elections, the LDP actually increased its number of seats and now controls both the upper and lower houses.[31] The apparent reason for Abe's success is the promise of economic reform, with the revitalization of Japan taking precedence over disagreements involving the future of nuclear energy. Consequently, while public opinion was able to make itself heard, the impact of the opposition was limited when other issues were seen as being more vital to Japan's integrity.

Beyond polls, which inherently only question a small selection of the wider population, there is another way to determine public interest in events: Google Trends. Using the search terms 'nuclear energy' and 'Fukushima,' the variety of interest around the globe in these topics can be determined on a scale of time against level of interest. In a global search (Figure 3), there was a spike in interest around 'Fukushima' during the time of the incident but there was an even larger jump in 'nuclear energy.' While interest to 'Fukushima' declined off over time, the search on 'nuclear energy' returned to its pre-incident levels within approximately half a year. In a German language search, 'Fukushima' attracted most of the attention while 'nuclear energy' remained of minimal interest. In Russia the reverse occurred where 'nuclear energy' drew intense interest, and since 2011 has continued to rise above previous levels, but 'Fukushima' sharply dropped after the initial burst in attention. It is interesting to note that in Germany, where public interest has mostly been on Fukushima with its negative connotations, the decision was made to curtail nuclear energy while in Russia, where the attention has instead been on nuclear energy in general, there are plans to continue building new nuclear reactors. In a non-nuclear country like Turkey, 'nuclear energy' has traditionally garnered little interest. That continued to be true during the incident even though 'Fukushima' made a large impact; into 2013, 'Fukushima' continued to be searched more than 'nuclear energy.' Finally, in Sweden, 'nuclear energy' has come to be even with pre-2011 levels but during the incident, both terms were actually of equal increased interest.

Public Opinion's Influence

Although it is difficult to measure public opinion, media attention has the potential to increase or decrease support for nuclear energy. A 2012 study by Sara K. Yeo of the University of Wisconsin-Madison found that high confidence in information can change opinions despite group affiliations or attitudes.[32] Nuclear incidents like Fukushima are global in media impact, as demonstrated by Belgian publications for the two months after the incident during which time 50 percent of coverage

Figure 3. Google Trends worldwide interest chart of nuclear energy (blue) and Fukushima (red), 2004-2013



was focused on nuclear-related domestic topics and the other 50 percent on international ones.[33] Comparisons drawn to the event equally span the globe, with reports on Fukushima often mentioning other nuclear incidents like Chernobyl. Fukushima ultimately became a segue into other issues like energy rather than serving as the sole objective of the article. Because media sources need sensational topics to attract an audience, Fukushima—whether in itself or as a lead into domestic issues at large—was strongly emphasized at the time. This intense interest in the media coincided with nuclear policy changes in a number of countries.

However, public opinion can also play a role in non-crisis, domestic nuclear situations. In both Germany and the UK, storage of nuclear and radiological waste has been a heated topic. Germany's industry, with fifty years of nuclear power history, continues to try to locate a suitable waste storage facility. For the past thirty-five years, there has been debate over the use of a salt mine in Goleben in northern Germany as such a facility. One existing site, the Asse nuclear waste site, had 126,000 drums stored between 1967 and 1978. But 14,000 drums are not properly documented, leading to questions of transparency. The tunnels are also filling with water, which could lead to groundwater contamination; yet as the salt tunnels are close to collapsing, remedying the situation would be risky and expensive. Additionally, there is debate about who should fund a new facility. The German Atom Forum, representing all utility operators, says that taxpayers should fund it; the Environmental Minister asserts that businesses should cover the expenses.[34] Meanwhile, in the UK, there was controversy over Sellafield. Sellafield, located in Cumbria, built a laboratory to study the option of burying highly active waste. Upon completion, it was announced that the laboratory would be turned into a radwaste storage facility. The resounding answer of the public was "No". As Nils Bøhmer of Bellona said, the public must be spoken to truthfully and openly.[35] According to Bøhmer, the "Sellafield Effect" was not that the public objected to the storage of radwaste but that they had been misled by Sellafield.

In the Russian city of Agidel, a NPP had begun construction but was halted in 1989 after the Chernobyl accident. Between 1992 and 2000, the economic health and population of the city drastically declined. By 2013 there were high levels of unemployment and no economic future for the city. Although the shutdown will continue through at least 2016, local residents support the restarting of plant's construction for the potential economic benefits. The main issue for the plant is therefore attaining funding, not public support.[36]

In the United States, Strathmore Minerals Corp. and Sumitomo Corp. of Japan created a joint venture, Roca Honda Resources LLC, to dig and operate a uranium mine near Mount Taylor, New Mexico, USA. The site contains the highest-grade known uranium deposits available in the United States. It is projected to make $2.2 billion in revenue during its operational life with 650 construction jobs and approximately 250 permanent jobs at the mine. As in the case of Agidel, economically beneficial proposals are attractive to the local business community. However, it faces strong opposition from environmental and some Native American groups.[37]

These outside groups, although not directly involved in the local community, have the power to lobby, demonstrate, and attract attention. As in the breach of the Y-12 National Security Complex on July 28, 2012, these groups have the potential to draw worldwide attention, possibly influencing opinion at the same time. In Turkey, when weighing plans for a reactor in Accuyu on the Black Sea, the government has been forced to take into consideration the European Greens, a European political party, who threaten to boycott Turkey's tourist industry if construction begins.[38] Similarly, in Russia, plans to build a Baltic NPP in the Kaliningrad region led environmental activists to write to financial companies that were intending on funding it, asking them not to do so.[39] And in Koodankulam (or Kudankulam), India, the construction of two 1,000 MWe VVER reactors was conceived in the 1980s but only begun in 2002.[40] The first reactor was due to be commissioned in December 2011, but it has been consistently postponed by local and anti-nuclear protests. Protesters, led by S.P. Udayakumar's People's Movement Against Nuclear Energy, insist that NPPs benefit industrial India, not the people, and would bring environmental risks.[41] In May 2013, the Indian Supreme Court weighed in by saying that the project would benefit the larger public interest.[42] Earlier, in February 2012, the Prime Minister went so far as to blame U.S. and Scandinavian NGOs for fomenting and financing the protests.[43]

The Future of Nuclear Energy

Before 2011, it was commonly held that there was a nuclear renaissance with a renewed interest in nuclear energy; all of this was put into question by the Fukushima-Daichii incident.[44] According to IAEA Director Yukiyo Amano in May 2013, the optimistic scenario for nuclear energy growth by 2030 is 100 percent. The pessimistic scenario is that it will only grow by 23 percent. While Amano knows that more energy will be needed in the future, he feels that renewables are also likely to grow during this time despite their higher costs to alternative sources.[45] Nevertheless, it seems that the nuclear energy will stay with us for a long time.

There are currently 436 reactors in thirty countries, with new construction in fourteen countries. Nuclear energy produces 14 percent of the world's energy.[46] The public's concerns regarding nuclear energy, limiting potential for future growth, generally fall into four categories: safety, capital cost, low prices for natural gas, and future spent nuclear fuel and radwaste. Incidents like Chernobyl, Fukushima, and Three Mile Island raise concerns about the safety for those living near NPPs as well as those worried about any environmental impact of such a disaster. A new NPP can also cost billions of dollars, often overrunning original budget estimations and suffering frequent delays, and some question such spending on NPPs at a time when natural gas is at an all-time low in price and is readily available.[47] Many countries, the United States included, are also still lacking a proper place to dispose of nuclear waste, leaving existing waste to be piled up in temporary locations.

Moreover, a forecast of nuclear energy between 2013 and 2030 projects that the number of reactors worldwide will decidedly increase. The total energy produced is expected to increase from approximately 370,000 MWe to 456,000 MWe on the low end and 740,000 MWe on the high end. The change will not happen in North America, which will stay the same, or in Western Europe, which will likely shrink in production of nuclear energy as it looks for safer, greener sources. Instead, the spur for change will largely be East Asia, rising from 80,000 MWe at the end of 2011 to between 153,000 MWe and 274,000 MWe by 2030. Small contributions will also come from Eastern Europe, the Middle East, and South Asia.[48] The bulk of the expansion will be from China, Russia, India, and South Korea.

Lessons Learned

In dealing with the public in regards to nuclear energy, there are five lessons that can be readily learned:

First, mass media has a powerful effect on public policy. As seen following Fukushima, consistent and pointed coverage can drive policy changes across the globe.

Second, dialogue with the public is worth having, although there is uncertainty in the outcome. The aforementioned study by the Canadian Nuclear Association demonstrated that the public can be largely ignorant of the deeper intricacies of nuclear energy and that that lack of knowledge leads to opposition. Outreach, requiring time and resources, can change opinions, but it can also solidify groups with opposing views by further publicizing the issue. It must also be kept in mind that when communicating with the public, jargon and technical concepts must be translated for wider consumption.

Third, as found by many polls, people tend to view existing reactors more favorably than new projects. Likewise, they also appear to tolerate the construction and operation of NPPs more than that of waste storage projects, which while necessary, are also viewed cautiously in countries ranging from the United States and Germany to the United Arab Emirates.

Fourth, by demonstrating a clear economic benefit, it is easier to attract the support of local and business communities. Economic gains encourage positive involvement by local communities, as the Agidel, Russia, and Mount Taylor, New Mexico, projects show.

Fifth, the public trusts data when it comes from independent sources, such as academia and scientists, than from various interested groups.[49]

A demonstration embodying a number of these conclusions can be seen in the success case of the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, USA. In essence, WIPP was attained because the public and its representatives were engaged from the beginning.[50] An independent organization was created, called the New Mexico Environmental Evaluation Group (EEG), to evaluate, criticize, and guide the U.S. Department of Energy (DOE) while ensuring the best for the people of New Mexico. Also, from the beginning, the people in charge of the WIPP project decided to interact with the public, conveying both good and bad news on the development of the project. This allowed for the building of a bridge of trust and led to the support both of the citizens near the site and of politicians representing the state spanning the local to the federal levels. The southern New Mexico community was also special in that the majority of residents were used to mining with both the economic benefits and the environmental risks that come with it. The public opinion on WIPP changed from majority of the local population in opposition to support during the twenty-five years of policy debate. The outset, the community saw that it could benefit from the development of WIPP and has since seen hundreds of millions of dollars poured into the region by the federal government.[51]

The conclusions from this final example, which can be applied to nuclear energy at large, are captured by DOE's Blue Ribbon Commission on America's Nuclear Future in 2012, which found that "public acceptance and policy preferences will continue to have an important, if not decisive, influence on nuclear materials management policies in the future."[52]

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Beyond Human Capital Development: Balanced Safeguards Workforce Metrics and the Next Generation Safeguards Workforce

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Abstract

Since its establishment in 2008, the Next Generation Safeguards Initiative (NGSI) has achieved a number of objectives under its five pillars: concepts and approaches, policy development and outreach, international nuclear safeguards engagement, technology development, and human capital development (HCD). As a result of these efforts, safeguards have become much more visible as a critical U.S. national security interest across the U.S. Department of Energy (DOE) complex. However, limited budgets have subsequently created challenges in a number of areas. Arguably, one of the more serious challenges involves NGSI's ability to integrate entry-level staff into safeguards projects. *Laissez fair* management of this issue across the complex can lead to wasteful project implementation and endanger NGSI's long-term sustainability. The authors provide a quantitative analysis of this problem, focusing on the demographics of the current safeguards workforce and compounding pressures to operate cost-effectively, transfer knowledge to the next generation of safeguards professionals, and sustain NGSI investments.

Introduction

The Next Generation Safeguards Initiative's (NGSI's) human capital development (HCD) pillar is designed to support the recruitment, education, training, and retention of the next generation of safeguards professionals who will be called upon to fill critical positions at the International Atomic Energy Agency (IAEA) and replace a retiring workforce across the U.S. Department of Energy (DOE) complex. Of particular alarm, a 2010 NGSI workforce analysis estimated that 82 percent of the safeguards workforce in 2009 would leave the workforce within fifteen years.[1] In response, HCD activities have focused primarily on the recruitment and training of the next generation of safeguards experts. Since 2008, NGSI has supported more than 450 safeguards internship and fellowship positions at the national laboratories, in addition to university curricula and short course efforts aimed at educating and training the next generation. At the Pacific Northwest National Laboratory (PNNL) alone, during 2008-2013 the NGSI supported more than seventy internships, averaging about 20-25 percent return rate each year and a 10 percent or better permanent hire rate. These new staff members bring intimate understanding of new tools and perspectives to tackle today's safeguards challenges, making them invaluable members of the organization. However, they enter the organization at a time when economic forecasts predict long-term budgetary recessions. As a result, managers are being pressured to do more with less. They must make decisions in the short-term to ensure critical work continues. These decisions make small sacrifices in the near term that end up having significant long-term negative consequences. For example, many organizations choose to slow or freeze the hiring process; others choose to limit or eliminate training and career development opportunities, viewing them as privileges that can be pursued when budgets are restored. Some start to rely more on inexperienced staff to complete the work, thereby marginalizing more experienced and costly staff. If these well-intentioned, but short-sighted choices continue, organizations will ultimately watch their best people depart, foregoing opportunities to transfer knowledge to the next generation.

This paper argues that managers who are interested in avoiding these long-term consequences can make the small, but conscious decision to approach the human resources element of project management with the long-term perspective in mind. This means crafting proposals that specifically use a near-optimal combination of staff, evaluating the staff distribution on existing projects, and adjusting the level of time each staff member spends on that project. This paper will also show how this approach at the individual project level can be scaled up to the program level. Federal managers can assess the suite of projects they support to determine whether small adjustments could be made on a more systemic level to help bring down costs while supporting effective engagement of those doing the work. More research is needed to generate data that might validate or invalidate this approach. For now, there is ostensibly little harm in taking this long view toward project management and making conscious decisions that will benefit the organization without sacrificing the projects in the process.

The Safeguards Workforce Development Challenge

An anecdote from a NGSI-sponsored event at PNNL in 2011 provides an introduction to the issues raised in this paper. (Examples and anecdotes from across the DOE laboratory complex are included without citing names or other identifying features for privacy reasons.) At a recent meeting of next generation safeguards professionals, one of the speakers, a co-author of this paper, explained that safeguards present an incredibly diverse set of topics for exploration, not only between the policy and technology spaces, but also within those spaces. He urged the audience to look upon the safeguards enterprise as an orchestra. "Learn to play an instrument extremely well," they were told. "In fact, strive for first chair in something. But remember you are part of an 'orchestra,' and for everything to work well, these seemingly 'separate instruments' in international safeguards must have some understanding of each other in order to 'play together.'"

After the talk, two members of this early-career audience approached the speaker, lamenting the fact that they were not "learning to play an instrument well." In fact, they were frustrated with their early safeguards careers because they could not focus on any one safeguards area and lacked opportunities to effectively team with those now engaged in safeguards projects. These statements may be outliers. However, if these early-career safeguards staff represent a larger population of discouraged staff, their statements may also suggest that NGSI's investments in recruitment and training may not be sustainable without more focused attention.

It is critical to U.S. government programs and organizations that are making significant investments in safeguards projects, technologies, and staff to examine carefully the sustainability of such investments and the return on those investments. One area worth exploring is how nonproliferation organizations manage their projects and current workforce demographics, particularly in environments where budgets plateau or decline. The hypothesis of this paper is that there is an optimal combination (or near optimal combination) of early-, mid-, and late-career staff members for any given project. When implemented, this combination can ensure the following:

- Late-career staff members are able to provide their expertise and pass on their knowledge to the next generation;
- Next generation safeguards professionals are significantly engaged early in their careers and are provided with a sustainable career trajectory, and
- Both of these objectives are accomplished in a cost-effective manner.

This optimal combination of staff will help facilitate the success and effectiveness of safeguards technology, policy, and engagement activities now and in the future.

The authors believe the results of this paper will contribute insights into program and workforce management that will support the long-term success of the NGSI's HCD objectives and advance the U.S. nonproliferation mission as a whole. At least two previous efforts have analyzed the safeguards workforce. One examined the existing DOE National Nuclear Security Administration (NNSA) workforce capabilities at the national laboratories[1] and another examined the skillsets that are needed to fill critical gaps in the safeguards workforce.[2] It is believed that the analysis presented here is the first to provide a mathematical analysis of safeguards workforce dynamics to explore effective management and long-term engagement of safeguards professionals.

Safeguards Workforce Group Descriptions and Dynamics

To facilitate the analysis, this paper arbitrarily divides the safeguards workforce into three groups, described as early-career staff, mid-career staff, and late-career staff.

Early-Career Staff

These are staff members within the DOE complex with less than five years total service and/or less than five years engagement in international safeguards. Given the success of the recruitment stage of the NGSI/HCD program (since 2008), there is a relatively large number of new staff, some fresh out of school or other HCD programs, entering the safeguards workforce and desiring significant on-the-job training (OJT) to develop their safeguards professional focus.[3]

There are a number of advantages to employing these staff on safeguards projects, including their relatively low cost compared to the other staff classes and their general enthusiasm as they begin their safeguards careers. Their lack of experience, however, means that most of them are not ready to take on significant leadership roles, such as principal investigator and project manager. Teaming with more experienced safeguards staff is required for mentoring, knowledge transfer, and OJT.

Mid-Career Staff

These are staff members within the DOE complex with at least five but not more than fifteen years of significant engagement in international safeguards. There is also an assumption that few staff members in this category will have worked full-time in international safeguards for their entire career. However, the group shall be defined as having worked a *relatively significant* fraction of their time (25 percent or greater will be used for this discussion) such that a credible and recognized safeguards professional focus has been developed and demonstrated. Included here are staff members who have worked on related issues, such as non-destructive assay (NDA) technology problems for arms control, which transfer readily to safeguards applications.

The primary advantage of using this staff class on projects is the combination of their generally cost-effective labor rates, experience, and track records. They make up most of the principal investigators and project managers, often serving both roles at once. Teaming with late-career safeguards staff is still a valuable activity for them, but they also have the opportunity to mentor early-career staff, in both project management and technical disciplines. The big disadvantage of the group is that their numbers are very small and their roles are many. Hence, in the construction of a successful safeguards project, both early-career and late-career safeguards staff must somehow augment them.

Late-Career Staff

These are staff members within the DOE complex with more than fifteen years of significant engagement in international safeguards or related fields. This group will be defined as those who have worked at least 25 percent of their time in safeguards and perhaps in related activities such that a credible and recognized safeguards professional focus has been developed and demonstrated in at least one safeguards area.

The primary advantage of this staff class is the nature of their experience, which has been repeatedly demonstrated over a long track record of successfully executed projects or applied technology experience. They are eminently qualified as principal investigators and project managers. They have a good eye for quality control/quality assurance for safeguards policy and technology projects, and they serve as the most-qualified reviewers. They are a valuable resource for knowledge transfer activities to both the early and mid-career safeguards staff, in both project management and technical disciplines. There are two disadvantages to this staff class:

- They are expensive relative to the other staff classes in the project labor structure; and
- They are disappearing from the workforce because of insufficient funding to support their continued work on the projects or because of natural career progression to retirement.

Safeguards Workforce Metrics

A model of any kind requires metrics, and the discussion just completed provides hints on metrics that one might choose. Hence, this paper defines, somewhat *ad hoc*, the metrics of *cost-effectiveness, knowledge transfer,* and *professional engagement* as an initial set of metrics to begin an analysis of current safeguards workforce dynamics. Each of these must be precisely defined in order for their relationships to be explored.

Cost Effectiveness

As good stewards of U.S. government funding, project and program managers must consider cost-effectiveness as a metric. This metric applies to the U.S. international safeguards enterprise as a whole and to the individual policy and technology providers that contribute to that enterprise.

The increase in overhead costs at the national laboratories is one factor influencing the cost-effectiveness of project implementation. Although laboratory investments, which partially drive overhead costs, are absolutely necessary to sustain cutting-edge national laboratory capabilities, anecdotal evidence from two national laboratories suggests that 1) growing overhead costs have generated rolling labor hour charge-out rate increases as high as 33 percent over consecutive seven-year periods, and 2) recent professional safeguards retirees report the ability to reduce their labor hour bid rates by as much as 40 percent when moving from national laboratory employee to private consultant status. If these trends are in fact representative, a more formal study on this specific issue across the DOE complex may be in order. Left unchecked, this trend may result in seasoned safeguards professionals becoming more isolated as time goes on, thereby losing consistent opportunities to contribute to emerging safeguards problems and mentor other staff. Safeguards staff are acutely aware of this issue and some have gone so far as to *fear* or *reject* promotions, recognizing that higher labor costs are correlated with less desirability for overall project finances and the ability to work on projects.

The purpose of this paper is not to make a case for an increase in federal funding necessarily. Rather, the compelling point is that cost-effectiveness is and will remain a significant safeguards workforce metric. Unfortunately, efforts directed exclusively to maintain cost-effectiveness of project execution and implementation could ultimately hinder other NGSI efforts to produce high-quality deliverables or cultivate a professional safeguards cadre for the future. Careful orchestration of project resources by project managers at the national laboratories and NNSA are necessary now to obtain optimal project implementation costs, while at the same time integrating other significant metrics for the future safeguards workforce.

For purposes of the project optimization mathematical model that is summarized in Table 1, cost-effectiveness is defined as follows:

A project is said to be cost-effective if the average charge-out rate for the safeguards policy or technology project is at or below a defined threshold c_e, measured in dollars per hour.

Example: A running example is provided here to provide additional clarity. Suppose that Marie is a mid-career safeguards professional whose labor rate is $100 per hour. The model assumes $100 to be the *cost-effective* rate c_e. Given a full-time equivalent (FTE) staff year of 1,840 hours, Marie's labor costs are $184,000 a year. Marie works with Andrew, a late-career safeguards professional with thirty-five years' service, whose labor rate is $133 per hour, and she also works with Joel, an early-career staff member, whose labor rate is $82 per hour. Given a single safeguards project that requires 1,840 hours of labor, and assuming any of the three can execute the project successfully, Marie will execute the project at exactly the cost-effective point, Joel can do it at an 18 percent discount, and if Andrew does it there is a 33 percent surcharge. Given the definition above, the project is considered *cost-effective* if Marie or Joel perform the work, but not if Andrew does.

Knowledge Transfer

One of the primary drivers for NGSI is to alleviate a human capital shortage and develop the next generation of safeguards professionals, given the demographics of the large number of late-career safeguards staff nearing retirement.[4] Hence, cost-effectiveness cannot be the only metric for success. Although university and specialized education in safeguards is necessary for a new and competent workforce, it is not sufficient for producing a fully qualified workforce. OJT and experience in working actual safeguards policy and technology problems provide critical learning experience that is necessary for effective knowledge transfer among staff.

For purposes of the model, *effective knowledge transfer* is defined as follows:

A project is said to illustrate *effective knowledge transfer* if the *ratio of staff hours between labor classes* implies a significant engagement by early-career staff as measured by the (relative) number of early-career staff hours executed on project. In particular, given that t_1, t_2, and t_3 represent the number of labor hours in any given safeguards project executed by early-, mid-, and late-career staff respectively, consider that *effective knowledge transfer* takes place if and only if $t_i/t_j \geq 1$, for labor class hours $i < j$.

Variable Definitions

α_i = Fractional labor rate for staff class i (i = 1,2,3 implies early-, mid-, and late-career staff respectively) exceeding the cost-effective rate, c_e. α_i is negative for staff labor rates less than the cost-effective rate, but α_i >-1 always, and typically on the interval [-0.5,0.5].

β_i = *Professional engagement metric* for individual members of staff class i (i = 1,2,3 implies early-, mid-, and late-career staff respectively), where $0 < \beta_i < 1.0$. This is the *minimally acceptable fraction of time* spent in safeguards projects by an individual safeguards contributor over an FTE staff year such that safeguards professional engagement is being developed and/or maintained.

c_e = *Cost-effective labor rate* in dollars per hour.

C = Total labor cost of a project in dollars.

$\bar{C}$ = Average labor cost rate of a project in dollars per hour.

f_i = Ratio of labor hours in staff class i (i = 1,2,3 implies early-, mid-, and late-career staff respectively) to total number of labor hours in a specified safeguards project.

FTE year = Full-time equivalent staff year, arbitrarily set to 1,840 hours.

g_i = Ratio of safeguards-focused labor hours for an individual in staff class i (i = 1,2,3 implies early-, mid-, and late-career staff respectively) to total number of labor hours in an FTE staff year. If g_i is greater than or equal to β_i, it is considered for purposes of this paper that the staff member is professionally focused or professionally engaged.

r_i = Staff labor rate, in dollars per hour, for staff class i (i = 1,2,3 implies early-, mid-, and late-career staff respectively).

t_i = Staff labor hours in class i (i = 1,2,3 implies early-, mid-, and late-career staff respectively) for a specified safeguards project.

T = Total number of labor hours in a specified safeguards project.

Example: The previous example established an understanding that if Marie or Joel worked the project by themselves, either result would be *cost effective.* But in neither of those cases, given the definition above, does *knowledge transfer* take place, since both Marie and Joel work the project independently. However, it is clear that if both Marie and Joel work the project together and equally (920 hours each), then the project will be both *cost-effective* and it will illustrate *knowledge transfer,* since in this case t_1/t_2 = 1.0. Thus, for every hour of Marie's time, an hour of Joel's time is also expended, and hopefully executed collaboratively in such a way that Joel is learning from Marie.

Professional Engagement

Finally, consider the metric of *professional engagement.* Professional engagement, i.e., actually working on safeguards projects for significant amounts of time, is critically important for the development of a professional safeguards cadre in the case of early- and mid-career staff and for the maintenance of that cadre as they move through their mid- and late-career phases. Given the total labor hours expended by a staff member in a staff year, and the mix of labor on one or more projects, are the employment fractions in every labor class sufficiently high that it can be claimed *professional engagement* is occurring at the *individual staff level*, independent of staff labor class? Asked another way, are a reasonable fraction of hours being executed by each staff participant on safeguards such that each can rightly claim safeguards as a profession?

For purposes of the model that follows, *safeguards professional engagement* is defined as follows:

> *Safeguards professional engagement* is being developed and/or maintained if, for *every staff performer* in labor class i, $g_i > \beta_i$ for specified values of class i, g_i being the ratio of the total number of safeguards labor hours executed by an individual staff member in staff class i to the total labor hours in a staff year and β_i is a constant.
>
> ***Example:*** Returning to the example, if Marie and Joel work a nominal 1 FTE (1,840 staff hours) safeguards project together and equally (920 hours each), the project is both *cost-effective* and illustrates *knowledge transfer* of at least one kind. Considering *safeguards professional engagement* as a third metric, and if this is the only safeguards project, Marie and Joel are each engaged half-time and Andrew not at all. Suggesting a minimum 25 percent FTE engagement in safeguards projects as the professional engagement criterion, then Marie and Joel meet the criterion, but Andrew does not. (The professional engagement criterion can easily be scaled by years of experience. For example, it might be specified that β_i = [1/2, 1/3, 1/8] for i = 1, 2, 3, respectively. Personal Communication, Dr. Leon Eric Smith, IAEA/SGTS, 2 January 2012.) Based on this metric, and given only this information, Andrew is not maintaining safeguards professional engagement.

Note, in the development of these three initial metrics, the progressive change in focus from the project itself *(cost-effectiveness)* to project labor class dynamics *(knowledge transfer)* to the individual project performer *(professional engagement).* Professional engagement as a metric focuses on the individual staff member, independent of staff labor class, and the fraction of time that the individual is actually engaged in safeguards as a profession versus a part time effort.

The Search for Optimization

An Initial Project Optimization Mathematical Model

The total labor cost of a specified project is given by

$$C = \sum_1^3 r_i t_i \,. \tag{1}$$

For purposes of a sample problem, assume that each class labor rate is expressed in terms of the cost-effective rate

$$r_i = (1+\alpha_i)c_e, \alpha_i > -1.0. \tag{2}$$

Dividing Equation 1 by T, the total number of labor hours in the project, and using Equation 2 and the definition of the f_i leads to the result,

$$\bar{C} = \sum_1^3[(1+\alpha_i)c_e\, f_i] \tag{3}$$

Constraining Cost First

Equation 3 provides some insight into the relations between staff mixes and cost-effectiveness on a per-project basis. To insist *as the first constraint* that cost-effectiveness be maintained, then the average labor rate for the project must not exceed the cost-effective rate, so that

$$\sum_1^3[(1+\alpha_i)c_e\, f_i] \leq c_e \tag{4}$$

Expressed this way, the cost-effective staff labor mix is now independent of the explicit value of the cost-effective labor rate, and solutions to the inequality require that

$$\sum_1^3[(1+\alpha_i)\, f_i] \leq 1.0 \tag{5}$$

All solutions to Equation 5 will satisfy the constraint of cost-effectiveness. The next two case studies serve as sample problems to explore the quantitative relationships between the three workforce metrics of cost-effectiveness, knowledge transfer, and professional engagement.

Case Study 1 – Balancing Cost-Effectiveness, Knowledge Transfer, and Professional Engagement

This case study examines the feasibility of balancing all three metrics to determine whether an optimal solution exists for cost-effectively managing safeguards projects.

Initial Conditions

Given the previous discussion of the staff classes, the mid-career staff will, by hypothesis, carry the majority of the workload and be, by definition, cost-effective. This is made explicit by the cost variable assignments of

$$\alpha_2 = 0 \tag{6}$$

$$\alpha_1 = -0.18 \tag{7}$$

$$\alpha_3 = +0.33 \tag{8}$$

The previous assumption is maintained of a cost-effective charge out rate, c_e, of \$100 per hour in an FTE staff year of 1,840 hours, so a cost-effective FTE is \$184,000, and for simplicity, the mid-career staff contribution is set at 60 percent for a single FTE safeguards project.

Applying these sample problem assumptions to a table of values (Table 1) is more enlightening than looking for formal solutions to the inequality in Equation 5.

Discussion of Alternatives and Trade-Offs

The table was generated *under the assumption that there is only one FTE safeguards project, i.e., 1,840 apportioned labor hours,* which allows us to examine the dynamics between the workforce metrics of cost effectiveness, knowledge transfer, and professional engagement. (In terms of the *Assumptions and Variable Definitions* previously discussed, this is the special case of $f_i = g_i$.) For the 1 FTE hypothetical project illustrated in Table 1, optimum values for the safeguards workforce metrics would be described by the following set of conditions:

- $\bar{C}$ (average labor cost rate of a project) is less than or equal to \$100 per hour,
- The ratio of the entry-level staff hours to late and mid-career staff hours is greater than or equal to 1, and
- The fractional engagement of staff at any career level equals or exceeds one-quarter full-time equivalent (that is, β_i, the professional engagement parameter, is 0.25 for every value of i).

If an optimum solution existed, there would be a staff mix case in the above table that is completely shaded. For the criteria desired, an optimum solution does not exist, but it is evident that some solutions are preferred to others. For Staff Mix Case 6, for example, five of seven parameters are acceptable, but at the price of late-career staff engagement that is too low. However, the table allows us to examine tradeoffs. Note that if the "standard is lowered" for "professional engagement" to one-fifth time, there is also now a solution for Staff Mix Case 5 that is similarly close to *optimum*. Case 5, shown in bold-italic-underlined text, specifies that 20 percent of staff labor hours are early career staff, 60 percent of hours are mid-career staff, and 20 percent of hours are late-career staff. The average labor hour charge out rate is \$103 per hour. For every late-career staff hour expended, an early career staff hour is also expended. For every late-career staff hour expended, three mid-career staff hours are expended. For every three mid-career staff hours expended, one early career staff hour is expended. In this case, five of these seven parameters are again optimized, but only by a conscious change in *standards* for professional engagement. Furthermore, the price paid to increase the late-career staff engagement from 0.15 to 0.20 FTE is about a 2.5 percent increase in the average cost per hour to deliver this hypothetical 1 FTE project.

Summarizing the project workforce metrics in this case study, and using these previous definitions, the project is not

Table 1. A safeguards project staff mix problem

Staff Mix Case	Early-Career Project Labor Load (f1)	Mid-Career Project Labor Load (f2)	Late-Career Project Labor Load (f3)	Average Project Labor Cost (in \$/hour)	Early/Late Labor Hour Fraction (f1/f3)	Mid/Late Labor Hour Fraction (f2/f3)	Early/Mid Labor Hour Fraction (f1/f2)
Case 1	0	0.60	0.40	113.20	0	1.5	0
Case 2	0.05	0.60	0.35	110.65	0.142	1.71	0.083
Case 3	0.10	0.60	0.30	108.10	0.333	2.0	0.166
Case 4	0.15	0.60	0.25	105.55	0.60	2.4	0.25
Case 5	**0.20**	**0.60**	**0.20**	**103.00**	**1.0**	**3.0**	**0.333**
Case 6	0.25	0.60	0.15	100.45	1.666	4.0	0.417
Case 7	0.30	0.60	0.10	97.90	3.0	6.0	0.50
Case 8	0.35	0.60	0.05	95.35	7.0	12.0	0.583
Case 9	0.40	0.60	0.0	92.80	-	-	0.667

strictly *cost-effective,* given the 3 percent premium paid above the desired $100 per hour, but it is close. The project planning clearly illustrates *knowledge transfer* from late-career to both early and mid-career staff, and it also illustrates *professional engagement,* assuming this one FTE project is worked by a three staff safeguards team composed of one early-career staff member at 20 percent, one mid-career staff member at 60 percent, and one late-career staff member at 20 percent.

Additionally, the table shows the trade off in the metric space when making other choices. Consider the effects of changes in the overall workforce metrics space as early-career staff are intentionally engaged at higher levels, an NGSI objective.

Effects of Increasing Early-Career Staff Engagement

Table 1 showed that maximizing early-career staff engagement generates a cost benefit, because of their generally discounted labor charge-out rates. But this cost benefit must be balanced with the other metrics. This result is somewhat intuitive, as entrusting a project primarily to early-career staff could degrade the quality of the deliverables and provide less opportunity for knowledge transfer from and professional engagement for the other staff classes.

Hypothetical Engagement Intervention

Suppose there was a desire to require an engagement level of 25 percent as the minimum requirement for the professional engagement metric for the early-career staff. What does this do to the other stated metrics? Examining the table, and leaving all other variables the same, the results can be analyzed under the conditions of the initial model.

> *Cost Effects.* Examining Staff Mix Case 6 in the table where f_1 is 25 percent, it is seen that cost-wise, there is an advantage: the average charge out rate moving from $103.00/hour to $100.45/hour, getting closer to the declared cost-effective threshold of $100 per hour.
>
> *Knowledge Transfer Effects.* Examining Staff Mix Case 6 in the table, the knowledge transfer values are quite favorable. The early- to late-career staff hour ratio, as a measure for knowledge transfer, is at five to three, quite acceptable, as is the mid- to late-career staff hour ratio of four to one. Note that nowhere in this table, by the *ad hoc* definition of effective knowledge transfer, do the mid-career staff provide effective knowledge transfer to the early-career staff, since the ratio of hours for early- to mid-career staff is everywhere less than 1, violating the declared criterion for effective knowledge transfer. This may not be a valid conclusion, and points out the difficulty in attempting to develop quantitative criteria for knowledge transfer to the entering work force Still, the attempt at a quantitative definition for knowledge transfer is enlightening, and one might argue that given the mid-career staff are burdened by project performance and management concerns, they may, in fact, be sufficiently distracted by these important duties to make them less available to pass on knowledge to early career staff.
>
> This might also be an interesting mathematical artifact, perhaps caused by choosing a *threshold* value for defining effective knowledge transfer from one class to another. An alternative approach might be to shade the table in intensity that goes from dark shades for low values of early to mid/late-career staff hour ratios to brighter shades for ratios that are 1.0 or higher, representing subjectively better knowledge transfer values.
>
> *Professional Engagement Effects.* What price was paid to gain the advantages of better cost-effectiveness and knowledge transfer? The penalty is paid by the late-career staff in the professional engagement space, since their engagement, looking at the table, now drops to 15 percent, moving further away from the suggested criterion of 25 percent FTE defined as the requirement for the maintenance of professional engagement. Then again, it may be that *some* late career staff can indeed maintain professional engagement, even at this low level of activity.

Safeguards Workforce Metrics Expansion and the Minimum Effective Safeguards Team

The discussion above suggests that other safeguards workforce metrics potentially exist, one of which is *total safeguards project volume*. In the current case study, for example, if there were *two* such projects as illustrated in Staff Mix Case 6 of Table 1, perhaps related, the late-career staff member would be engaged at 30 percent FTE, which is a much more acceptable value from a professional engagement standpoint.

Continuing this initial three-member safeguards team proposition, there is an emerging "quantum" like result for what might be termed the *minimum effective safeguards team.* A second full FTE safeguards project now scales, using Staff Mix Case Study 6 in Table 1, to requirements for 0.5, 1.2, and 0.3 FTE of early, mid, and late-career staff respectively. This suggests that the "quantum" solution that meets all stated Safeguards workforce metrics is a minimum-sized safeguards team of four staff members (one early-, two mid-, and one late-career) requiring two FTEs of safeguards project volume, which in our hypothetical example would cost $368k given our $100 per hour cost effective rate. This team is comprised of (1) an intern transitioning to early career staff status, or an early career staff member working half-time, (2) one mid-career Safeguards policy specialist teamed with one mid-career Safeguards technology specialist, each working at .6 FTE, and (3) a single late-career staff member as project advisor working at .3 FTE.

It is now clear that there is a method that provides significant insight into project planning that goes beyond simple cost-effectiveness to include other important safeguards workforce metrics. The final case study that follows, drawn loosely from an actual PNNL project, illustrates an iterative approach to this type of planning.

Case Study 2 – Iterative Project Planning and the Use of Interns

Provided is an example from a now concluded project at the Pacific Northwest National Laboratory that was sponsored by the Office of Nonproliferation and International Security. PNNL project staffing included a senior staff member (mathematician/physicist) as the principal investigator (PI), an early-career staff member (nuclear engineer), and an intern (international policy specialist).

The cost structure is asymmetric and has the values $[\alpha_1, \alpha_2, \alpha_3] = [-0.81, -0.10, +0.32]$ with respect to the intern, early-career, and late-career staff members respectively. Again, this means that the intern comes at an 81 percent discount, the nuclear engineer at a 10 percent discount, and the senior staff member at a 32 percent surcharge compared to the cost-effective labor rate. The iterative project planning process is shown to lead to a project mix that optimizes cost-effective project performance, significant knowledge transfer, and professional focus for all project staff.

Cost Effectiveness. It was established that the project will be cost-effective as long as the condition stated in Equation 5 holds. It is clear that the senior staff member hours are the ones that must be limited in order to meet the cost-effective metric. Consequently, an initial distribution is chosen such that the intern and nuclear engineer have equal hours with the senior staff member making up the balance of hours so as not to exceed the average cost effective FTE rate. The result here is:

$$[f_1, f_2, f_3] = [0.21, 0.21, 0.58] \text{ FTE}, \qquad (9)$$

which just meets the cost-effectiveness condition.

Knowledge Transfer. Given the nature of this particular project, and the need for significant senior staff involvement because of the experience required, the project mix in Equation 9 might be acceptable. However, it would be better if the early-career nuclear engineer hours could balance with the senior staff member hours in order to meet the knowledge transfer metric of 1.0. To satisfy this, one can iterate to a model with an equal number of early and senior career staff labor hours. The result is:

$$[f_1, f_2, f_3] = [0.12, 0.44, 0.44] \text{ FTE} \qquad (10)$$

This result again just meets the cost-effectiveness metric, but at the same time now illustrates effective knowledge transfer between the senior staff member and the more junior nuclear engineer. Note that the knowledge transfer values to the intern, however, do not meet our criterion from the first case study.

Professional Engagement. The second iteration is not affording the intern a very meaningful experience, being engaged at only the 12 percent FTE level. For the final iteration on this project planning that meets most workforce metrics, the intern contribution is pushed up to 25 percent, and the remaining 75 percent is split between the senior staff member and the more junior nuclear engineer. The result is:

$$[f_1, f_2, f_3] = [0.25, 0.375, 0.375] \text{ FTE} \qquad (11)$$

An interesting consequence of this result is that it more than meets the cost-effective metric on a standard FTE labor year, bringing it in instead at 88 percent of the cost effective value, or said another way, it provides the project at a 12 percent discount. Hence, the cost-effective use of interns is clear. Table 2 provides a summary of these iterative cases in a manner similar to Table 1. The iterative cases move from top to bottom in Table 2.

Table 2. Example of iterative staff mix planning

Iterative Case	Early-Career Project Labor Load (f_1)	Mid-Career Project Labor Load (f_2)	Late-Career Project Labor Load (f_3)	Average Project Cost ($\bar{C}$ in $/hr)	Early/Late Labor Hour Fraction (f_1/f_3)	Mid/Late Labor Hour Fraction (f_2/f_3)	Early/Mid Labor Hour Fraction (f_1/f_2)
Cost-Effectiveness	0.21	0.21	0.58	100.00	0.36	0.36	1.0
Knowledge Transfer	0.12	0.44	0.44	100.00	0.27	1.0	0.27
Professional Engagement	0.25	0.375	0.375	88.00	0.666	1.0	0.666

To summarize, Table 2 illustrates just one of many solutions, each of which can be tailored for specific requirements or circumstances. The point of the example is to show how an *intentional* iterative approach to project staffing can lead to not just human capital development (HCD), but human capital development and significant *engagement (HCD&E).* Finally, note that these results can be used to scale a project at a given staff mix and hence determine the requirements for full-time employment in any labor class.

Full-Time Intern Employment Scaling. Suppose there is the desire to hire a full-time intern, at the staff mix indicated in the *Professional Engagement* row above, since it is an optimized staff mix with respect to the stated metrics for this particular project. The results can be scaled in that row of the Table by a factor of 4 to obtain the *full-time intern investment requirement.* The result is

$[f_1, f_2, f_3] = [1.00, 1.5, 1.5]$ FTE (12) or a total of four FTEs.

Full-Time Early- and Late-Career Staff Employment. Similarly, a full-time early-career staff member, which in this case also includes a full-time late-career staff member, at the given project mix desired, requires

$[f_1, f_2, f_3] = [0.666, 1.0, 1.0]$ FTE (13) or a total of 2.666 FTEs.

Case Study Summary. Case Study 2 has provided an illustration that shows not only an iterative approach to balancing safeguards workforce metrics, but also the flexibility in applying them. For the particular project at hand, there was a requirement for direct senior staff leadership, as the PI, as well as knowledge transfer from the PI to the nuclear engineer. This was accomplished at some cost to the knowledge transfer activity between the PI and the intern, but the cost is measurable and displayed, providing the ability for project management to make choices in the parameter space.

Conclusions

The quantitative model and case studies presented in this paper demonstrate that even a rudimentary quantitative formulation provides a helpful glimpse into the dynamics facing the safeguards workforce in an austere resource environment. With additional research, the ideas presented here may inspire both better and/or additional quantitative workforce metric definitions and better methods for analyzing them. Beyond analysis, it is also important to consider the consequences of failing to act on the insights developed in the analysis. The NGSI program itself constitutes an intervention, given its focus on replenishing the retiring workforce with a new generation of safeguards experts. While successful on one level, this intervention remains incomplete. The NGSI HCD program is well-positioned to take advantage of the "last few standing" with insights and personal experience of the great safeguards accomplishments of recent history. NGSI's HCD program has helped facilitate the transfer of knowledge through lectures, mentoring, and documentation projects. However, an element of the program designed to effectively enable early and mid-career staff members to apply these lessons learned to the safeguards work of today is missing. It is time to move beyond this initial HCD approach towards one of *human capital development and engagement*. Our case studies suggest to us that there are solutions that can be intentionally sought which are better than simply letting the dynamics of the problem evolve unmanaged to "invisible hand" solutions.

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Securing China's Nuclear Power Plants

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Abstract

By 2012 China had fifteen reactors in operation with an aggregate installed capacity of about 12 GWe. In addition, twenty-seven reactors, capable of producing a total of 29 GWe, are under construction. While the pace of rapid nuclear development has slowed in the wake of Fukushima, China now plans to grow its total nuclear capacity to 40 GWe by 2015 and 58 GWe by 2020—making the Chinese nuclear industry by far the fastest growing industry in the world. While China has been focusing more on improvements in nuclear safety at its nuclear facilities since the Fukushima accident, it continues to strengthen nuclear security as well. In particular, the Fukushima accident may increase the interest of terrorists in targeting those power reactors.

Since September 11, 2001, China has substantially advanced its physical protection system, with a switch in focus from the traditional "guns, gates, guards" approach to an effective mixed approach, combining personnel with modern techniques. Then-Chinese President Hu Jintao emphasized at the 2012 Nuclear Security Summit that, "In the future, China will further take nuclear security measures, make sure the security of its own nuclear materials and facilities, improve the overall nuclear security." This paper examines the specific and detailed physical protection approaches that are currently applied to China's nuclear power plants, and recommends further steps to improve China's existing nuclear security system.

China's Nuclear Power Development and Fukushima Accident

By 2012 China had fifteen reactors in operation with an aggregate installed capacity of about 12 GWe, which accounts for less than 2 percent of China's electricity generation (see Table 1). In addition, twenty-seven reactors, capable of producing a total of 29 GWe, are under construction–making the Chinese nuclear industry by far the fastest growing industry in the world. Until the Fukushima nuclear accident in March 2011, China had been in a period of rapid development of its nuclear power, a change from the moderate development pace at which it was moving prior to 2005. Based on the "Medium- and Long-Term Nuclear Power Development Plan (2005-2020)" issued officially in 2007, China planned to install a total nuclear capacity of 40 GWe by 2020. Many officials and experts expected that the number would rise to more than 80 GWe by 2020.

The pace of rapid nuclear development has slowed in the wake of Fukushima, however. In its initial reaction, China's State Council decided on March 16, 2011, that China would suspend approval of all new nuclear power stations, conduct comprehensive safety inspections on all existing plants, and review all nuclear projects including those under construction. In October 2012, after comprehensive safety inspections on all plants in operation and under construction, the State Council issued the new "Medium- and Long-Term Nuclear Power Development Plan (2011-2020)," which reconsiders the nuclear safety and development pace seriously and cautiously.[1] The new plan includes: (1) a sound return to normal construction, reasonable control of the construction pace, and a steady and orderly path forward; (2) a *scientific* layout for new reactor sites, with only a limited number of coastal sites with fully proven projects (the inland nuclear power projects will not be considered because the government fears a shortage of cooling water in a nuclear accident); and (3) a requirement that all new nuclear power projects should meet the world's highest safety standards, which mean, in essence, that it must meet the safety standards of the third-generation (or Gen III) type reactors.

Based on this new nuclear development plan, only a few new reactor construction projects will be approved before 2016. China now plans to grow its total nuclear capacity to 40 GWe by 2015 and 58 GWe by 2020. While the nuclear development pace will be slowed in the near future, China's long-term goal of nuclear development will not be changed significantly. China continues to emphasize the role of nuclear energy.

Since the Fukushima nuclear accident, China has officially approved a number of plans to enhance its nuclear safety standards. All emphasize that nuclear power should be developed under conditions that assure nuclear safety and the development pace should be controlled on that basis. As some Chinese officials emphasize, China's nuclear power is shifting from a rapid development to a steady state with a focus on safety.

The State Council approved in May 2012 the "Comprehensive Safety Inspection Report on Civilian Nuclear Facilities" and the "Twelveth Five-Year Plan and the 2020 Vision of Nuclear Safety and Radioactive Pollution Prevention" submitted by National Nuclear Safety Administration. The inspection report indicated that most of the nuclear power plants meet the existing domestic nuclear safety regulations and the standards of the International Atomic Energy Agency.[2] The inspections revealed several major nuclear safety issues related to nuclear power plants, such as, some nuclear power plants lacked adequate guidelines for severe accident prevention and mitigation; some plants did not meet the new requirements on flood prevention; and some could be affected by a tsunami. The inspection report required the plants to solve these issues and make improvement by 2015 in a phased manner, including urgent improvements by the end of 2012, such as an increase of mobile backup emergency power system and mobile pumps at power plants to ensure the operation of cooling system at any conditions.

In October 2012, the State Council executive meeting also approved the "Nuclear Power Safety Plan (2011-2020)," which was submitted by the National Energy Administration. The State Council emphasized several points at that meeting, including nuclear power development must follow the principle of safety first in the entire process of nuclear power planning, construction, operation, and decommissioning and related industries; safety upgrades of nuclear power units in operation and construction should be carried out continually; the build-up of nuclear power safety standards and regulation system should be accelerated and nuclear accident emergency management and response ability should be enhanced; and public oversight and cultivation of public opinion on nuclear power should be strengthened.[3]

While China has been focusing more on improvements in nuclear safety at its nuclear facilities since the Fukushima accident, it continues to strengthen nuclear security as well. In practice, some nuclear safety measures in China include parts of security approaches, such as physical protection measures. Moreover, some safety measures, including an increase of mobile backup emergency power systems and mobile pumps, aiming to prevent the loss of cooling function at the nuclear reactor and the spent fuel pools would also be applied to cases of nuclear sabotage against those facilities. Indeed, the Fukushima accident may increase the interest of terrorists in targeting those power reactors and spent fuel pools by incurring loss of all power supply and loss of cooling function at those facilities.

During the Seoul Nuclear Security Summit in March 2012, China released a report on the progress it had made on improving nuclear security over the past two years. As it stated, China "has taken active measures to implement the outcome documents of the Washington Nuclear Security Summit and made significant progress," including increasing its input in nuclear security, improving relevant regulations and standards system, and upgrading the level of nuclear security management.[4]

Table 1: Operating power reactors in China by 2012

Reactors	Capacity(Mwe)	Type	Design	Operation
Qinshan I #1	320	PWR	China	1991
Daya Bay #1	984	PWR	Franatom	1994
Daya Bay #2	984	PWR	Franatom	1994
Qinshan II #1	650	PWR	China	2002
Qinshan II #2	650	PWR	China	2004
Lingao #1	990	PWR	Franatom	2002
Lingao #2	990	PWR	Franatom	2003
Qinshan III #1	728	Candu	Candu	2002
Qinshan III #2	728	Candu	Candu	2003
Tianwan #1	1060	VVER	Russia	2007
Tianwan #1	1060	VVER	Russia	2007
Lingao #3	1086	PWR	China	2010
Qinshan II #3	650	PWR	China	2010
Qinshan II #4	650	PWR	China	2011
Lingao #4	1086	PWR	China	2011

China's Nuclear Security: Policies and Regulations

President Hu Jintao emphasized at the 2012 Seoul Nuclear Security Summit that, "the threat of nuclear terrorism cannot be overlooked. And it is a long and arduous task to effectively manage the security and safety risks in the development and utilization of nuclear energy."[5] He further stated, "In the future, China will further take nuclear security measures, assure the security of its own nuclear materials and facilities, and improve the overall nuclear security…" He proposed:

- First, stick to the scientific and rational nuclear security concept, build confidence in developing nuclear energy, face up to the nuclear security risks, enhance the security and reliability of nuclear energy, and promote the secure and sustainable development of nuclear energy.
- Second, reinforce nuclear security capacity building, undertake national responsibilities for nuclear security, build and improve the legal and regulatory framework of nuclear security, strengthen the training of nuclear emergency response personnel, and increase research and development input.
- Third, deepen international exchanges and cooperation, raise the global nuclear security level, strengthen the universality of international legal instruments on nuclear security, promote nuclear security standards and norms, actively provide nuclear security assistance, and help developing countries improve nuclear security.
- Fourth, eliminate the root causes of nuclear proliferation and terrorism, stick to the purpose and principles of the UN Charter, adhere to the new security outlook of mutual trust, mutual benefit, equality, and collaboration, and insist on solving hotspot issues and international disputes through peaceful means.

China has established a comprehensive legal and regulatory system to secure its nuclear materials and nuclear facilities. Since it became an IAEA member in 1984, China has established material control and accounting (MC&A) systems in accordance with IAEA safeguard guidelines (INFCIRC/153) and physical protection system based on INFCIRC/225 recommendations. China has also signed a number of international agreements related to nuclear safeguards and security: In 1989, China acceded to the 1980 Convention on the Physical Protection of Nuclear Material; in October 2008, China ratified the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM); in August 2010, the country ratified the International Convention for the Suppression of Acts of Nuclear Terrorism. Finally, China has implemented its obligations under relevant UNSC resolutions, including Resolution 1540 and Resolution 1887.

In 1987 China approved and issued the "Regulations for Control of Nuclear Materials of the People's Republic of China."[6] In order to facilitate the implementation of the regulations, in 1990 China approved and issued the "Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China."[7] China also has issued some other major relevant implementation rules, including "Rules on Physical Protection for International Nuclear Materials Transport" (1994), "Rules on Inspection of Nuclear Materials Control" (1997), and "Rules on Security of Nuclear Power Plants" (1997). Moreover, China has issued a number of technical guidelines based on the 1997 Regulations and the related implementation rules, including the Nuclear Facilities Physical Protection Guidelines, the Guidelines for Physical Protection of Nuclear Materials during Transport, and the Guidelines of Access Control at Nuclear Facilities. It should be noted that all these related regulations and rules were issued at least a decade ago and, while the government states that they have been improved and updated, the new regulations and rules have not been issued as of this writing.

The China Atomic Energy Authority (CAEA) is responsible for nuclear material control and security of nuclear facilities. China's National Nuclear Safety Administration (NNSA) also involves the physical protection of civilian nuclear facilities. The CAEA has adopted a licensing system for securing nuclear material and facilities. The operator of the nuclear material facilities must apply for a nuclear material license, if the facility holds more than ten effective grams of U-235 or any quantity of plutonium. To get the license, the operator must establish MPC&A systems that meet the regulation guidelines provided by CAEA. Moreover, China uses its inspection regime to verify the compliance of licenses. Inspection activities include verifying the integrity of accounting records, the physical inventory change, measurement, and quality control systems, material balance, and effectiveness and reliability of physical protection measures. If a facility is found in violation of these regulations, it would be punished by warning, penalty, or revoking the license—depending on the seriousness of the violation.

China's Physical Protection System

Since September 11, 2011, China has made significant progress on its physical protection system of nuclear facilities and has significantly improved its MPC&A system, with a focus on switching from the traditional "guns, gates, guards" approach to an effective mixed approach, combining personnel with modern techniques. The MPC&A requirements and approaches have become much more stringent. The major changes include a security approach based on the China's derived design basis threat (DBT); an effective physical protection system (PPS); uses of modern physical protection, material control, and material accounting technologies; requirements for in-depth vulnerability assessments and performance tests of the security system; improvements of operator organization of nuclear security and guard force training and equipment; and strict requirements for personnel screening. The major factors that caused these changes include the 9/11 attacks in the United States; international legal obligations, such as the 1980 CPPNM and its 2005 amendment and UNSCR 1540; and recommendations from the IAEA including revisions of INFCIR/224.

In the early 1990s, when China began to operate it is nuclear power reactors, the plants relied mainly on armed guards and did not apply modern physical protection systems. In the late 1990s, China began to study the modern PPS theory through China-U.S. cooperation, including the lab-to-lab activities. Since the early 2000s, China has developed and applied security systems based on modern PPS theory. For instance, Qinshan plant, China's first indigenous nuclear power plant started operations in 1991, began to update its security system in 2002 based on a modern PPS theory, and, subsequently, the system passed its final test in 2007.[8]

In 2008, the China National Nuclear Safety Administration issued the Nuclear Facility Physical Protection Guidelines. It requires the operator of a nuclear power plant to establish a complete, reliable, and effective physical protection system. The system should assure coordination among the three elements of detection, delay, and response. Also, the system should perfect the functions of various physical protection equipment, and combine personnel prevention measures with modern techniques.[9]

The 2008 guidelines require all new nuclear facilities to comply with all physical protection standards, and old facilities with lower protection technology and standards to upgrade to the required standards. The operator must establish a professional organization to oversee the plant's physical protection. The organization must be staffed with an appropriate number of personnel, and the operator must assign a high-level leader of the plant to be in full charge of the physical protection work. Also the security personnel must pass stringent and regular exams, and receive rigorous training and assessment. [10]

Based on the relevant Implementation Rules issued in China and IAEA guideline recommendations, the design of PPS at China's nuclear facilities are required to follow several major principles, including: 1) the basis of the threat evaluation; 2) application of the concepts of defense in depth and detection balance; 3) the graded approach; 4) vulnerability analysis; 5) contingency plans; 6) security in design; and 7) protection of confidential information.[11]

China has also widely applied technical measures for the *detection* function as the first line of defense, which includes perimeter detection, access control, video camera assessment, and personnel identification.[12] These measures have effectively strengthened the PPS by increasing its detection probability and reducing detection time in the event of an intrusion.

Additionally, China has applied a number of technical measures to the *delay* function at nuclear facilities. The delay function is, as the second line of defense, designed to increase adversary penetration time for entry into and/or exit from the nuclear facility, providing enough time for the on-site guard forces to respond. The physical barriers implemented at the nuclear power plants to delay an adversary include double fences with intrusion detectors and clear zone between them. Moreover, the facility operator is required to have an emergency plan to respond to unauthorized removal of nuclear materials or sabotage of nuclear facilities, and to conduct an annual exercise. China's nuclear power plants are also protected by armed forces and security guards on duty twenty-four hours a day. The armed force is mainly responsible for the security of the entire area within the facility, access control, and preventing intrusion from outside adversaries. The security guards are responsible for the security of specific locations inside the facilities and managing the operation of a physical protection system.

Furthermore, the operator of a nuclear power plant is required to improve and update its physical protection system based on evolving situations and to maintain the system's effectiveness. Before 1998 the concept of vulnerability analysis of physical protection did not receive attention and there was no evaluation and theoretical analysis about physical protection systems.[13] Now Chinese facilities are required to conduct in-depth vulnerability assessments with identified vulnerabilities corrected in a timely manner.[14] Also the operator is required to use technical approaches to strengthen the reliability of the security system, including performance tests of detection and assessment and the use of reliable and compensatory techniques.[15] China does not, however, conduct realistic "force-on-force" exercises to test the performance of its nuclear security systems.[16] Moreover, the lessons learned from the Y-12 National Security Complex security breach by three protesters including an 82-year-old nun show that the security system needs to have performance testing at all levels from "terrorist" type adversary to protesters.

The Design Base Threats for China's Nuclear Power Plants

Before the September 11, 2011, attacks, China's power reactors were mainly designed to protect from natural disasters or accidents. However, since the 9/11 attacks, China has made substantial changes in its nuclear security approaches, such as protecting nuclear facilities against design basis threat (DBT), including both outsider and insider adversaries.

The 2008 Nuclear Facility Physical Protection Guidelines require all civilian nuclear facilities, including nuclear power reactors, to apply a security approach based on the DBT.[17] The 2008 Guidelines require an evaluation of various potential threats the nuclear facilities could face. The major elements of the evaluation of potential threats include the attributes and characteristics of potential criminals, the motivations and intentions, scale and capabilities, as well as possible means and tactics that could be used. And the potential criminals include outsiders, insiders, and a collusion of both. The 2008 guidelines further require that a competent authority must approve the DBT for a nuclear power plant before its use as a basis for the physical protection system.

While the new 2008 Guidelines require DBT, it has no clearly defined standards for nuclear power plants. The operators typically design their own DBTs on a case-by-case basis according to a number of factors, including the socioeconomic situation in the surrounding area.[18] Based on the general requirements of DBTs by the 2008 Guidelines, the operators of the nuclear power plants study discuss and evaluate the DBTs based on current threat level with a number of relevant organizations, including the China Atomic Energy Authority, the Ministry of Public Security, the Chinese Armed Police Force, and the local security department. Eventually, the designed DBTs are required to get approval from the CAEA. The details of the designed DBTs are kept secret from the public, however.

There are arguments in China whether China should have official, comprehensive, and unified DBT standards for all its nuclear power plants. Some experts argue that it is very difficult and possibly not necessary to have unified DBT standards, because of the difference in local situations. However, some suggest China should have a clear, specific, and unified DBT standard for nuclear facilities. Li Ganjie, director of China's NNSA, even suggests it should establish international unified DBTs standards for nuclear power plants, thus each country can design its security system for new reactors based on the international standards, and revalue and take measures to update its security system for operating reactors according this international standard.[19]

Since September 11, 2001, Chinese experts have done scenario analysis on sabotage against China's nuclear power plants. In 2005 China published an authoritative book *Management of Nuclear and Radiological Terrorism Incidents*, based on a research project of China Academy of Engineering. The project involved a number of experts from distinguished Chinese nuclear agencies including NNSA, China Institute of Atomic energy, China National Nuclear Corporation, and China Academy of Engineering Physics.[20]

Based on the design features of the power reactors and the characteristics of terrorist attacks, these experts identified five potential nuclear power plant targets that terrorists could attack.[21] These targets are: 1) attacks against the reactor building, which would result in a larger-scale release of radioactive materials and thus incur serious consequences and social and psychology disruption; 2) thefts of nuclear materials for terrorist activities, including creating radiological dispersal devices, including passive, explosive (i.e., dirty bomb) or atmospheric dispersal of the nuclear materials thus inciting public panic; 3) attacks against relevant facilities of a reactor which impact on reactor operations, including reactor shutdown, thus result in relatively serious effects on economic and social psychology; 4) attacks against conventional facilities at nuclear power plants that result in certain effects on economic and social psychology; and 5) attacks against plant workers that lead to a collapse of the reactor operation and/or command organization, thus incurring an impact on social psychology. Among these five attack modes, the experts concluded, the first attack mode, i.e., attacks against the reactor building, is the only case that can result in severe consequence of radioactive release. All others would mainly result in impacts on social and psychological disruption.

Chinese experts further discussed sabotage scenarios against the reactor and spent fuel pool buildings. The potential threats from outsider sabotage against reactors could include the use of portable weapons and limited amounts of explosives. However, the experts believe that the current design base accident (DBA) and security measures for nuclear power reactors protect against these threats. The current DBA also provides protection for the containment of the reactor against the impact of a small airplane. However, it does not protect against a commercial plane and heavy weapons, including missiles, which would damage the containment and cooling system of the reactor, thus resulting in reactor core meltdown and a radioactive release. In addition, if explosives are used inside the reactor building, the explosion could also lead to some radioactive release. Also the commercial plane and missiles would damage the spent fuel pool and create a loss of the cooling water. This would overheat the spent fuel incurring a radioactive release, or damage the spent fuel directly leading to a radioactive release.[22] However, many experts argue that the risk of these attacks by commercial planes and heavy weapons is extremely low in China.

As far as the insider threat is concerned, based on China's current security situation, these experts conclude the worst case is that the insider sabotages the main control room of the reactor or the reactor building itself, which could lead to unpredictable consequence. However, the consequences from all other scenarios involving insider threats, including reactor shutdown, breaking the primary coolant loop, and a cutoff of the power supply system, would be stopped or mitigated by DBAs for the reactors and other current safety and security measures. In the discussions, the insider threats are considered mainly from individual acts, instead of a well-organized group.[23] However, a collusion of insiders and outsider, which would pose a great threat to nuclear facilities, as emphasized by other countries, should not be ignored in China. As Li Ganjie, the director of the NNSA, noted: the existing DBT for nuclear power plants could be unable to resist attacks from larger scale and well-organized terrorist groups with powerful weapons.[24]

The licensee of a nuclear power plant is required to be fully responsible to secure its nuclear facility. However, the operator itself would not be able to afford the cost of dealing with the new potential security threats, including attacks from commercial planes and heavy weapons. In addition, the current DBTs for nuclear power plants only take into account potential threats during peacetime. It does not address wartime threats, using various weapons such as long-range missiles that could target the reactors. Some officials and experts in China suggest the central government should take an appropriate responsibility for security of nuclear facilities. This would be necessary, in particular, if a new security system is required to deal with threats including potential attacks from commercial planes and heavy weapons. In doing so, it is imperative to clarify through legislation, the responsibilities between the government and the operators of nuclear power plants.[25]

Furthermore, enhancing DBT standards would increase the capital and operating costs of nuclear power plants thus reducing the competitiveness of nuclear power. While the operator of a nuclear power plant has relatively better profits from selling commercial electricity than that of other fuel cycle facilities and has less difficulty applying current security requirements at the power plant, it would be reluctant or unable to afford to take further security measures including preventing larger scale attacks. Thus, one challenge is how to balance the new security requirements with the economics of nuclear power development. As Chinese officials emphasize, the new security requirements "should not only be ensured to prevent effectively from or defense against rational (a certainty of design base threat) external attacks, but also promote a favorable development of nuclear power."[26]

A Graded Approach for China's Nuclear Power Plants

China's management of nuclear security and physical protection is mainly based on the 1990 "Rules" and the IAEA related recommendations (INFCIRC/225 Rev.4). The 2008 Guidelines require the operator of nuclear facilities to design its security system based on principles for protection of category I, II, and III nuclear materials and facilities. These include graded protection measures, according to the relative attractiveness, the nature of nuclear materials and facilities, and potential consequences. Table 2 and 3 show the three categories of civilian nuclear facilities in China and their required corresponding physical protection measures.[27]

Reactors with power larger than 100 MW (th) belong to category I nuclear facilities and should be secured by corresponding physical protection measures. For example, the physical protection measures for nuclear power reactors should include: twenty-four-hour armed forces for physical protection areas; alarm and monitoring system at all access entrances; permits or badges held by authorized personnel and vehicles that enter the areas; strict control of non-site personnel access, including registration procedures, and full-time escort by site-personnel after access; a "double-men and double-lock" system for the vital area; and a hardened central alarm station.[28]

The operator is required to divide the physical protection area of a nuclear power plant into three security areas: the controlled area, the protected area, and the vital area. The vital area is inside a protected area, which should be located inside a controlled area. The operator should take management and physical protection measures according to divided areas. The vital area contains facilities and equipment, including the reactor main control room, reactor and auxiliary buildings, spent fuel building, the generator room, and main coolant pump.

The 2008 Guidelines also provide specific requirements of physical barriers for each area. The controlled area should have "one-layer" physical barriers, either barbed wire fences or a wall. The height of the barriers has to be higher than 2.5 m. If a wall is used as a physical barrier, the thickness of wall has to be greater than 24 cm. The protected area should have "two-layer" physical barriers, such as barbed wire fences (see Figure 1). The height of the outer layer should be higher than 1.5m; and the inner one should be higher than 2.5 m. The distance between the two layers has to be greater than 6 m. The physical barriers for a vital area can include buildings or connections with fences and walls. If buildings are used as physical barriers, they must be sturdy in all aspects. The delay function of the wall, floor and ceiling should be no less than that of a layer of reinforced concrete with a thickness greater than 20 cm.[29]

Some Specific Measures for Physical Protection at China's Nuclear Power Plants

Since September 11, 2011, China has enhanced physical protection at its nuclear power plant by personnel management, technical measures, or a combination of both, including access control, intrusion detection, and video monitoring systems.

The operator of a nuclear power plant is required to take effective personnel and vehicle access control measures for the physical protection areas.[32] For example, persons or vehicles authorized access to the three areas should be limited to the minimum necessary. Authorized persons or vehicles can enter the areas only after their identification is verified, and are required to display the pass or badge after entering the secured areas. The access authorization for non-site personnel and vehicles are strictly limited. After entering the protected and vital area, the authorized visitor is required to be escorted full time by personnel authorized unescorted access. A "double-men and double-lock" rule for the vital area is applied. Barriers to reduce vehicle speed are set up outside the access point of controlled area. Structures to protect from vehicle collisions are established outside the access of protected area, and entry of

Table 2: Three categories of civilian nuclear facilities in China[30]

Category I	Category II	Category III
• Facilities containing category I nuclear materials • 100 MW(th) reactors or larger • Spent fuel pools with some new discharged fuels and the total radioactivity greater than 1017 Bq Cs-137 • Spent fuel reprocessing facilities • High-level liquid nuclear waste storage and processing facilities • Others not mentioned above	• Facilities containing category II nuclear materials • 2-100 MW(th) reactors • Middle-level liquid and high-level solid nuclear waste storage and processing facilities • Spent fuel pools requiring active cooling systems and not cover by category I case • Facilities where any on-site criticality accidents without control measures can pose impacts beyond 0.5 km from the facility perimeter • Others not mentioned above	• Facilities containing category III nuclear materials • Less than 2 MW(th) reactors • Low-level liquid and middle-level solid nuclear waste storage and processing facilities • Facilities where direct exposure dose rate without shielding measures is larger than 100 mGy/h at 1 meter away • Facilities where any on-site criticality accidents without control measures can pose impacts within 0.5 km from the facility perimeter • Others not mentioned above

Table 3: Physical protection measures of civilian nuclear facilities in China[31]

Category I	Category II	Category III
• 24-hour armed policemen at access points in the three areas • Alarm and monitoring system at all access entrances • Pass or badge held by authorized personnel and vehicles to enter three areas • Strict control of non-site personnel and vehicles to access; full-time escort with site personnel after entering the protected and vital areas • A "double-men and double-lock" rule for the vital area • Radioactive material detection systems installed at access to the protected and vital areas • Emergency power backup system • A control center to manage physical protection system	• 24-hour armed policemen at access points in controlled and protected areas. • Alarm and monitoring system at all access entrances • Pass or badge held by authorized personnel and vehicles to enter each area • Strict control of non-site personnel and vehicles to access; full-time escort with site personnel after entering the protected areas • Radioactive material detection systems installed at access to the protected area • Emergency power backup system • A system control center to manage physical protection system	• Facilities located in controlled area • Communication and monitoring system at all access Entrances • Pass or badge held by authorized personnel and vehicles to enter the area • Emergency power backup system • An office with security personnel on duty

vehicles into the protected area is limited to designated parking areas.

In addition, the nuclear power plants have widely applied advanced equipment and technology for the access control. For example, detection systems for radioactive material and prohibited items have been installed at access points to the protected and vital areas. To control access to facilities, the plants use mobile barrier gates, metal detecting gates, electric retractable gates, floor-to-ceiling turnstile doors with barcode reading systems (see Figure 2), biometric identification systems, and alarm and video monitoring systems at all access points.[33]

Also, the licensee is required to install intrusion detection systems at the physical barrier surrounding the protected and vital areas. The detectors within the free zone between the double fences for the protected area, and at the inner fence of the double fences if needed, consist of a variety of technologies, which cover all required detection areas. Intrusion detectors should also be installed at the entrances and exits, tunnels and ditches that cross the boundaries of protected and vital areas where there are no guards on duty. The intrusion detection systems for parameter control use a number of high-tech sensors including microwave detectors, active infrared sensors, electric field sensors, ported coaxial cable systems, taut wire sensors, vibration or tensile detectors, fiber optical sensors, and video motion detectors. The system should be tested on a regular basis. Moreover, the video monitoring system should also be set up at those places required for intrusion detection. [34]

Furthermore, each nuclear power plant is required to have a permanently staffed and hardened central alarm station located in the vital area. These stations are protected by armed forces on duty twenty-four hours a day, and access is strictly controlled and minimized. Also, the licensee is required to set up a group and prepare detailed contingency plans to prevent nuclear terrorist acts and nuclear accidents. This group must also consult with local relevant divisions, including the public security office, the fire fight department, and the environment protection office. The final plans should be documented at the local public security office. As required, the operators must strictly implement the plans.[35] The operator is also required to conduct an annual exercise to assess and validate

Figure 1. Daya Bay Nuclear Power Plant, photo taken by the author in January 2013. The double fences for the protected area can be seen in this photo.

the prepared contingency plans. The central government has also established an interdepartmental nuclear contingency coordination system[36] and documented the state's contingency plan, which complements the plan prepared by the operator. The state and operator contingency plans are required to be regularly reviewed and updated.

Finally, China has enhanced its nuclear security capabilities through international cooperation. These cooperative efforts include: In 2006, the CAEA and the IAEA established a "CAEA-IAEA Joint Training Center on Nuclear Safeguards and Security" with an aim to strengthen the training capability on nuclear safeguards and security; In January 2011, China and the United States signed the Memorandum of Understanding for Cooperation in Establishing a Center of Excellence (COE) on Nuclear Security; and in November 2011, China established the National Nuclear Security Technology Center, which is responsible for the construction, management and operation of the COE. The center will serve as a forum for exchanging technical information, sharing best practices, developing training courses, and promoting technical collaborations to enhance nuclear security in China and throughout Asia.

Some Suggestions for Further Strengthening China's Nuclear Security

Over last decade, China has substantially advanced its physical protection system, with a switch in focus from the traditional "guns, gates, guards" approach to an effective mixed approach, combining personnel with modern techniques. Then-President Hu Jintao emphasized at the 2012 Nuclear Security Summit that, "In the future, China will further take nuclear security measures, make sure the security of its own nuclear materials and facilities, improve the overall nuclear security."[37] China should take further steps to install a complete, reliable, and effective security system to ensure that all its nuclear facilities, including nuclear power reactors, are secured with adequate standards to defeat the threats it is likely to face. To improve China's existing nuclear security system, the following measures are recommended.

China needs to update and clarify its rules and guidelines for DBT for nuclear facilities, including nuclear power reactors. Although the new 2008 Guidelines require DBTs, it has no clear and unified standard. Meanwhile, China's current DBTs for nuclear power plants may be unable to resist extreme adversary scenarios, such as 9/11-type attack. It should review and up-

Figure 2. An entrance access to a protected area at Daya Bay nuclear power plant. The floor-to-ceiling turnstile doors and the gate with detector are shown in the photo. Credit: Photo provided by a security expert at the plant, January 2013.

grade the basis used for designing physical protection for the nuclear reactors to ensure it reflects the threat as perceived after the 9/11 attacks. The DBTs should include the full spectrum of plausible adversaries and tactics. Some experts argue that China has been unable to construct a more systematic and rigorous approach to DBTs mainly because it lacks familiarity with the necessary concepts and processes.[38] To design effective DBTs, China should significantly enhance the R&D investments into this aspect and learn best practices from other nations through bi-lateral and international cooperation. While some nuclear experts in China argue that it is not necessary to have clear and unified DBT standards because of the different situations at various nuclear sites. However, it is imperative to have at least a minimum DBT standard that includes protection against a modest group of well-armed and well-trained outsiders; a well-placed insider; and both outsiders and an insider working together, using a broad range of possible tactics.[39]

China should also update its old 1987 Regulations and 1990 Rules, and issue the new strict and clear Regulations and Rules based on at least the minimum DBT standard. Meanwhile, China needs a strong system of enforcement to ensure the new Regulations and Rules are effectively implemented.

Moreover, China should conduct realistic performance tests at all levels from terrorist-type adversaries to protesters as shown in the case of Y-12 National Security Complex security breach.[40] Currently the operator is required to do in-depth vulnerability assessments and performance tests of their security systems, however, they do not include the realistic "force-on-force" exercises. No Chinese regulations require such tests. As the newly issued INFCIRC/225/Revision 5 recommends,[41] China should use realistic "force-on-force" exercises to test the performance of its nuclear security systems' ability to detect and defeat intelligent adversaries using asymmetric attacks. China may lack the experience and capabilities to carry out such tests at actual sites; for instance, how the safety and security of the nuclear facilities could be unaffected during the tests. In addition, China may lack the technologies, including laser engagement systems, to conduct on-site combat simulations. However, the newly established National Nuclear Security Technology Center, responsible for the construction, management, and operation of China's Center of Excellence on Nuclear Security, is considering using such tests. China could also learn the practice of "force-on-force" exercise through China Atomic Energy Authority and U.S. Department of Energy cooperation. For example, Chinese experts can be invited to witness such exercises at U.S. sites, as it has done with other countries, including France and Japan.

Furthermore, China should promote a robust nuclear security culture. To ensure that modern security systems are actually implemented effectively, a strong security culture is imperative. Moreover, security culture is linked closely with nuclear safety culture and safeguards culture. Enhancing 3S (safety, security, and safeguards) cultures are key enablers for large-scale nuclear energy growth as China plans.

President Hu Jintao emphasized the importance of "promoting nuclear security culture" at the 2010 Nuclear Security Summit.[42] However, many Chinese professionals in the nuclear field doubt that the terrorism threat is realistic in China. They argue that the risk of terrorist sabotage against nuclear power plants and the resulting radioactive release is very low because the terrorists lack the means or tools to conduct such attacks and China's current security system should be good enough to prevent those attacks.[43] Instead, some nuclear experts view the most realistic threat of nuclear terrorism is from the dispersion of radioactive material via a radiological dispersal device.[44] Moreover, some managers and employees at Chinese nuclear plants do not appreciate the need for the advanced and stringent MPC&A systems.[45] In addition, some argue that the stricter the security standards are employed, the higher the capital and operating costs the operators have to pay.

In fact, the possibility of insider sabotage against nuclear facilities cannot be ruled out, in particular, as China increasingly becomes a market-oriented society and increasingly corrupt. Outsider terrorist attacks may someday pose a real threat to China's nuclear facilities. For example, the terrorist forces of the so-called "East Turkestan," which have close links with international terrorism, have long been recipients of training, financial assistance, and support from international terrorist groups.[46] In practice, a terrorist attack elsewhere would also doom China's ambitious plan of nuclear power development. A security incident, on the scale of Chernobyl, would definitely damage the development of China's nuclear power. China should have a targeted program to assess its security culture and find ways to improve it. Moreover, it is necessary to have a program to ensure the reliability of the personnel who will be operating the system, including security screening.

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44. Senlin, L. 2011.The Status of Research on Nuclear Security Technology in CIAE, presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14, 2011, Beijing, China.
45. Yun Zhou, *op .cit.*
46. See, e.g., http://www.mps.gov.cn/n16/n983040/n1988498/1988553.html.

Book Review

By Mark L. Maiello,
Book Review Editor

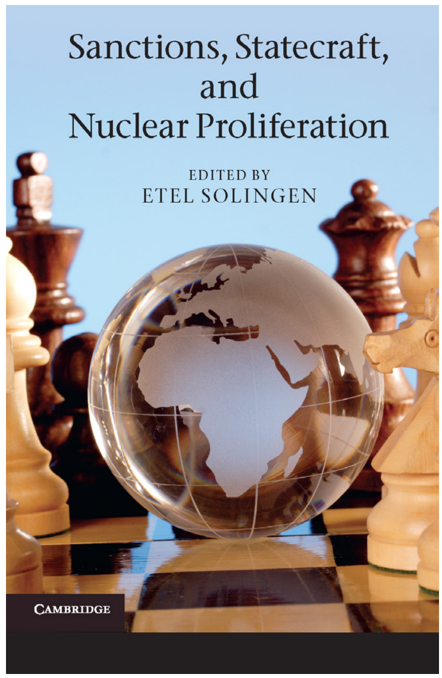
Sanctions, Statecraft, and Nuclear Proliferation
Etel Solingen, Editor
Softcover, 388 pages
ISBN 978-0-521-28118-8
Cambridge University Press, Inc., 2012

This scholarly work is intended for the serious student or practitioner of political science. Edited by renown University of California, Irvine professor Etel Solingen, it focuses on the efficacy of international sanctions and inducements, i.e., how they function—if at all—to influence a nation to choose a nonproliferative course over its more dangerous alternative.

Contributors include research analysts, fellows, and scholars of international relations, government, politics, and political science from Cornell University, UCLA, Tufts, the National Defense University, the East-West Center and the RAND Corporation.

This work covers four areas of research: the composition of various inducements, the various types of inducements, the success and failures of inducements in Libya, Iraq, Iran, and North Korea, and ten dilemmas of nonproliferation as summarized and analyzed by the editor from the contributing authors' chapters.

Being a political science effort, there are analyses of data culled from public and, where possible, governmental records that are used to quantify—to the extent possible—the effects of inducements on the four primary targets of recent statecraft efforts. For example, Chapter 3, "Empirical trends in sanctions and positive inducements in nonproliferation," by Celia L. Reynolds and Wilfred T. Wan (both from the same institution as the editor), is supported by no less than sixteen tables of data in two appendices of the chapter spanning thirty-eight



pages! No other chapters come close to this output of data. For the novice, these data may be overlooked without loss of understanding. A few chapters sport clear, neatly designed graphical illustrations. The data are illustrative by revealing the factors that are tracked by political scientists in their efforts to ascertain the effectiveness of sanctions and positive inducements.

The strength of the book is the depth of the analyses. Be prepared to be totally immersed (though not drowned) in political science terminology. If this reviewer who was new to this type of work can complete a read of this book and walk away educated and unscathed, so will you. But what exactly can one expect to absorb from the effort? The contributors have analyzed a number of characteristics of the four target regimes and discussed how their domestic social, economic, and political structures have influenced the effectiveness of sanctions and positive inducements.

The approach to this study can be illustrated by the examining Part II, which is devoted to explaining the escalating types of sanctions from positive inducements to threats of military actions. Miroslav Nincic discusses positive inducements in the context of the three national characteristics mentioned above. The responsiveness of nations to outside influence is at least partly affected by the effect of the influences on the well-being of the constituencies supporting the ruling regime. And this is intertwined with domestic economics and the social order. As the editor writes in her introduction, one must always ask who wins and who loses within the nation targeted by influences and sanctions (*cui bono* and *cui malo*, respectively).

Take the case of Iran. Contributor Alireza Nader elucidates the history of Iranian-targeted U.S. and UN sanctions including the positive inducements, and then, in the context of that nation's structure, evaluates how Iran sidestepped sanctions, turning them on their head to use for internal and international political leverage. He then analyzes whether sanctions were ultimately effective under certain circumstances. Nader's chapter is a fascinating tour of how contemporary Iran functions and how its reason for existence as an anti-American state helps it to resist international sanctions. One learns how the Revolutionary Guards have become major stakeholders in the nation's economy by controlling key sectors. With both internal security and commercial interests supported by a government pledged to stop American imperialism, the Guards have evolved into a sanctions target – possibly the bull's-eye or at the least, the lynchpin for inducements designed to off-track the Islamic Republic's relentless course to nuclear weapons. Nader uses the recent history of the last thirty years to explain the internal political factions of the country and ties them to personalities that scholars should recognize including the recently retired (by term limits) Mahmoud Ahmadinejad. The Islamic Right is composed of Reformists (in name only) and Pragmatic Conservatives, both of which favor a less closed economy and a less strident nuclear policy. Iran's third rightist "party" the principalists, espouse a harder domestic and foreign policy line. There is an Islamic Left, but the rightist factions dominate Nader's analysis. These factions and the economic and societal fallout from the institutions dominated by the factions, e.g., the Revolutionary Guards are key to the influence of sanctions. Elucidating the machinations of the Iranian government and its economy in the context of crafting nonproliferation sanctions is a side benefit of this book.

"…North Korea has not only been impervious to nonproliferation efforts but to analytical consensus as well… The response to an engagement policy that is not credible is indistinguishable from an opportunist forever seeking more concessions." These quotes are taken from the opening to Stephan Haggard's and Marcus Nolan's chapter on the assessment of sanctions as applied to the Democratic People's Republic of Korea (DPRK) and reflect the intransigence of that inward looking dictatorship. Both the type of regime it harbors and the political coalition that maintains it factor heavily in its response to economic sanctions. North Korea's extraordinary capacity (as the authors put it) to inflict costs on its population is another major factor in its response to sanctions. Simply put, a regime that survived a famine (mid-1990s) is unlikely to be swayed by sanctions unless they are targeted to cause difficulties of a very troubling sort—an admittedly difficult but not impossible task.

The authors proceed to discuss the complications of coordinating the sanctioning efforts of China, South Korea, Japan, Russia and the United States—a task nearly as difficult to achieve as successful sanctions. Of interest here are the economic policies of both China and South Korea and the concomitant effects they produce on a "cooperative" sanctioning regime. South Korea's approach has been economic cooperation with the North without conditions (this changed after 2007 with the inauguration of a new South Korean government) while China's export of luxury items to the DPRK in defiance of UN Security Council Resolution 1718, increased during the years 2002 – 2007. Thus, cooperation among nations with agendas and regional perspectives of their own is, mildly put, problematic.

Despite, or perhaps because of, its scholarly nature, this book has value outside of its main purpose. The authors provide a great wealth of background information on the nations they focus on. This information—the recent history of Iran and North Korea—would not be easily accessible without wading through historical treatises. Receiving this formative information in the context of nuclear nonproliferation makes them palatable and, frankly, quite interesting. The goals and platforms of the political parties of Iran as explained unveiled this otherwise rarely discussed aspect of that nation. Another windfall was the revelation that the thousands of pages of government documents seized from Iraq after Saddam Hussein was toppled revealed significant facts about that nation's reactions to sanctions that can be analyzed by political scientists for future applications.

Readers with reason to delve into a modern analysis of the effects of sanctions will find this work invaluable. It is also possible to glean much from it for those entering the fields of sanctions and political science for the first time. Certainly, the political science data collected and its scrutiny are made clear; but perhaps easier to digest introductions to political science exist elsewhere. Few however, will be as superbly bound to the study of nuclear non-proliferation as this finely honed edition is.

Bumps in the Road

By Jack Jekowski
Taking the Long View Editor and Chair of the INMM Strategic Planning Committee

A recent communiqué from INMM President Ken Sorenson to the Executive Committee (EC) used the term "bumps in the road" as he described the continuing efforts by the EC to strategically address the various confounding circumstances that have reduced attendance at our Annual Meeting, including restrictions placed on conference attendance by U.S. government agencies, and the general global economic malaise that exists today.

I equate "bumps in the road" to events that arise from the commonly used strategic/scenario planning terms "critical uncertainties" and "wild cards." Both of these terms have been used in this column before to describe those situations that can cause a dramatic change in the path to the future, and for which we must be prepared to respond to with robust strategies.

Still appropriate and repeating from the last Taking the Long View column: how we effectively deal with these external influences, or bumps in the road, from a strategic perspective, will determine the future health and viability of the Institute, and should be the focus of all Institute members.

INMM's Global Presence and Its Role in Enhancing International Collaborations

In a continuing effort to improve the awareness of the Institute's value to the global community, the EC has charged the Strategic Planning Committee (SPC) to help develop "the story" that can be told about the impact the Institute has had, and continues to have, in making this a safer world. One of the recent efforts by the SPC to accomplish this task has been the development of some maps that provide a visual reference about the reach and contributions of the Institute. One such attempt is shown in Figure 1 that provides a perspective on the global reach of the Institute, identifying the official chapters and affiliations. This figure is included in a new informational "one-pager" that is being reviewed by the EC. This graphic portrays the INMM's international presence with six U.S. and ten international chapters, as well as the affiliation with standards organizations and entities with formal collaborations. The

Figure 1: INMM's global presence

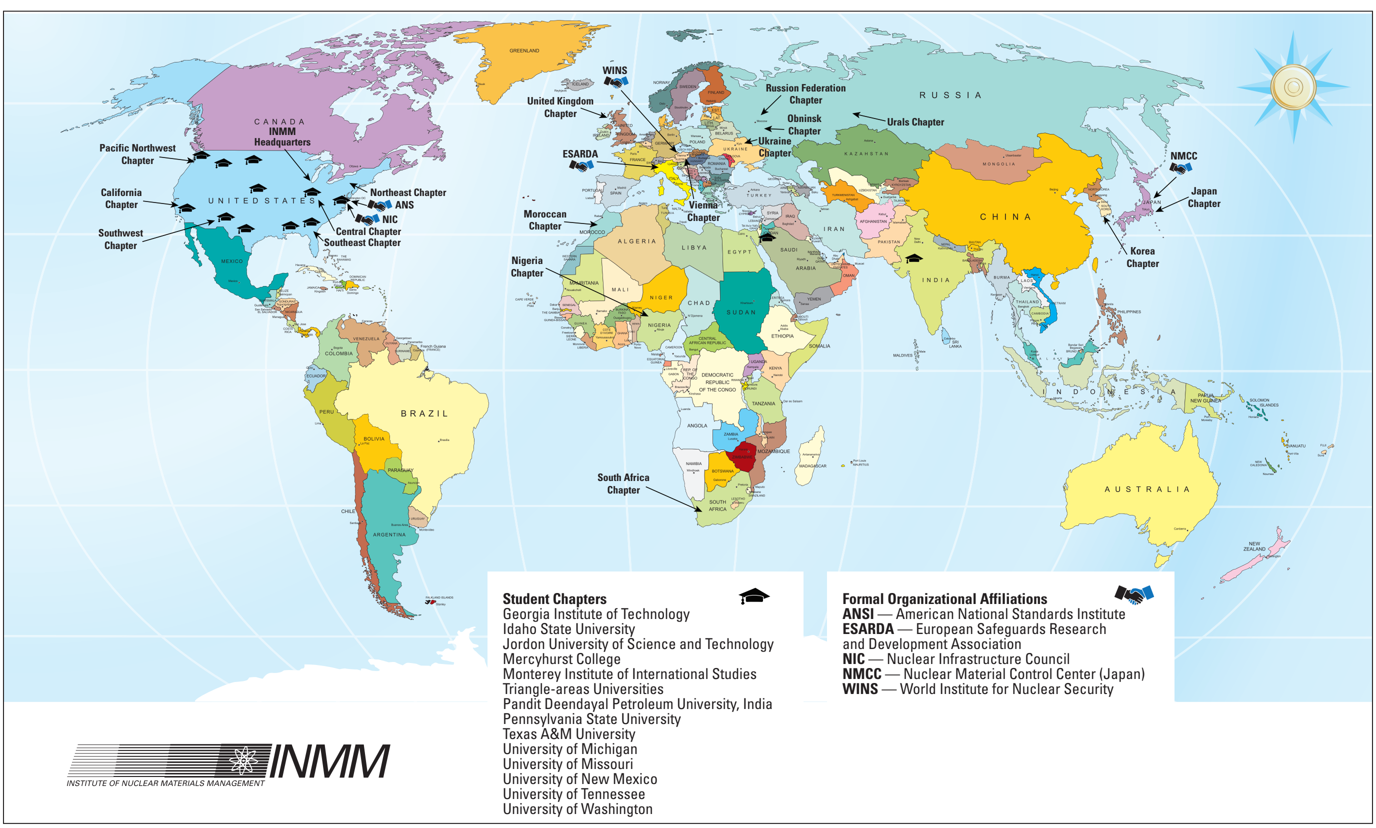
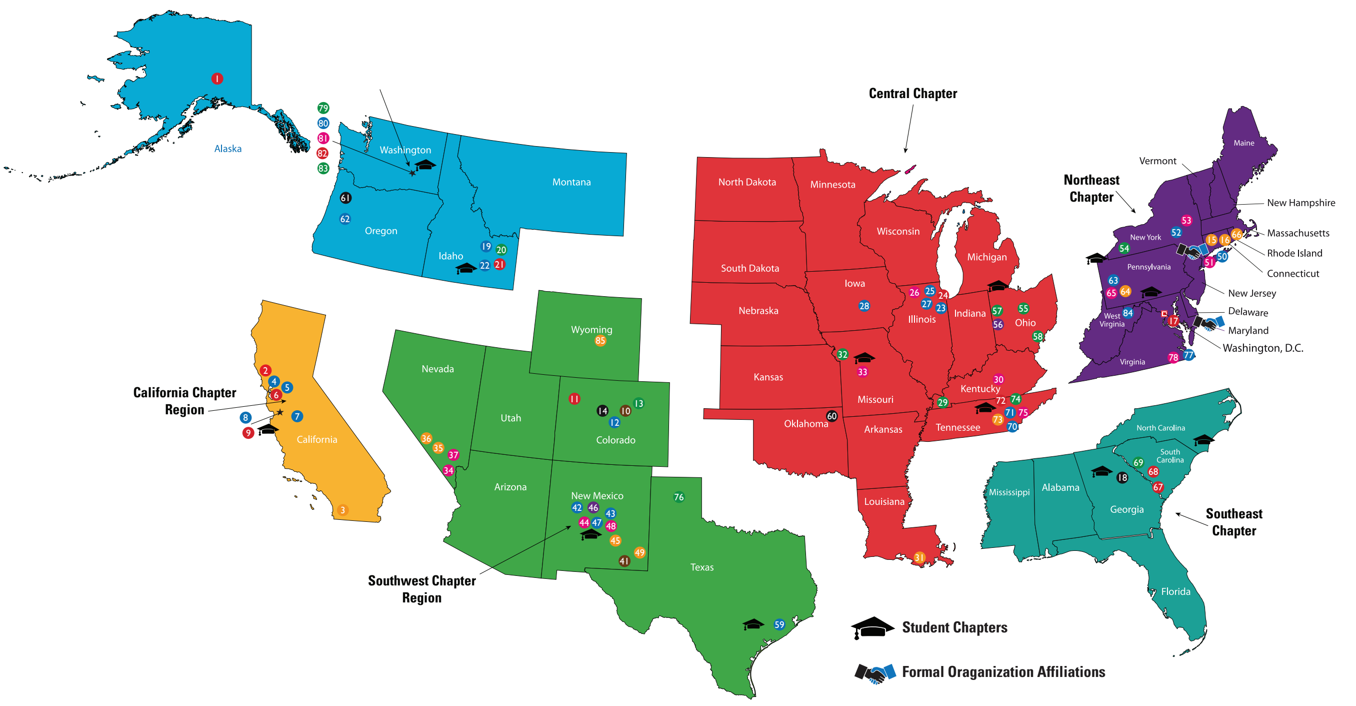


Figure 2: INMM U.S. region and student chapters



Alaska
1 Arctic Energy Office

California
2 Berkeley Site Office
3 Energy Technology Engineering Center
4 Lawrence Berkeley National Laboratory
5 Lawrence Livermore National Laboratory
6 Livermore Site Office
7 Sandia National Laboratories
8 SLAC National Accelerator Laboratory
9 SLAC Site office

Colorado
10 Golden Field Office
11 Grand Junction Office
12 National Renewable Energy Laboratory
13 Rocky Flats Closure Project
14 Western Area Power Administration

Connecticut
15 16 Northeast Home Heating Oil Reserves

District of Columbia
17 Washington, DC Headquarters

Georgia
18 Southeastern Power Administration

Idaho
19 20 Idaho National Laboratory
21 Idaho Operations Office
22 Radiological Environmental Sciences Laboratory

Illinois
23 Argonne National Laboratory
24 Chicago Office
25 Fermi National Accelerator Laboratory
26 Fermi Site Office
27 New Brunswick Laboratory

Iowa
28 Ames Laboratory

Kentucky
29 Paducah Gaseous Diffusion Plant
30 Portsmouth/Paducah Project Office

Louisiana
31 Strategic Petroleum Reserve

Missouri
32 Kansas City Plant
33 Kansas City Site Office

Nevada
34 Nevada Site Office
35 Nevada National Security Site
36 Yucca Mountain
37 Office of Civilian Radioactive Waste Management

New Jersey
38 Northeast home Heating Oil Reserve
39 Princeton Plasma Physics Laboratory
40 Princeton Site Office

New Mexico
41 Carlsbad Field Office
42 Inhalation Toxicology Research Institute
43 Los Alamos National Laboratory
44 Los Alamos Site Office
45 National Training Center
46 NNSA Service Center
47 Sandia National Laboratories
48 Sandia Site Office
49 Waste Isolation Pilot Plant

New York
50 Brookhaven National Laboratory
51 Brookhaven Site Office
52 Knolls Atomic Power Laboratory
53 Schenectady Naval Reactors Office
54 West Valley Demonstration Project

Ohio
55 Columbus Environmental Management Project
56 EM Consolidated Business Center
57 Miamisburg Closure Project
58 Portsmouth Gaseous Diffusion Plant

Oklahoma
60 Southwestern Power Administration

Oregon
61 Bonneville Power Administration
62 National Energy Technology Laboratory – Albany

Pennsylvania
63 Bettis Atomic Power Laboratory
64 National Energy Technology Laboratory – Pittsburgh
65 Naval Reactors Laboratory Field Office

Rhode Island
66 Northeastern home Heating Oil Reserve

South Carolina
67 Savannah River National Laboratory
68 Savannah River Operations Office
69 Savannah River Site Office

Tennessee
70 East Tennessee Technology Park
71 Oak Ridge National Laboratory
72 Oak Ridge Site Office
73 Office of Scientific and Technical Information
74 Y-12 Plant
75 Y-12 Site Office

Texas
76 Pantex Plant and Site Office
59 National Energy Technology Lab – Sugar Land

Virginia
77 Thomas Jefferson National Accelerator Facility
78 Thomas Jefferson Site Office

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79 Hanford
80 Pacific Northwest National Laboratory
81 Pacific Northwest Site Office
82 Richland Operations Office
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Wyoming
85 Naval Petroleum Reserve No 3 – Casper

Institute also has formally commissioned fourteen student chapters at renowned educational institutions, two of which are international. With more than 1,300 individual members worldwide, and the peer-reviewed *Journal of Nuclear Materials Management* published quarterly, the INMM is recognized as an international technical organization helping to create a safer and more secure future for the world. Through a large annual meeting held in July each year, and various technical workshops sponsored by the INMM Technical Divisions, the Institute provides a unique opportunity to present leading-edge science and technology breakthroughs; learn about current and future policy developments and other opportunities associated with nuclear materials management and nonproliferation; engage directly with leading experts and authorities from around the world; and educate and develop the next generation. In addition, the Annual Meeting provides a cost-effective mechanism for collaborators from nations around the world to network, have face-to-face technical discussions, and arrange complementary meetings and facility visits.

INMM's U.S. Presence and Its Role in National Standards

Previously, the SPC had created a map of the Institute's U.S. presence for discussions with our supporters and stakeholders in the U.S. Department of Energy (DOE) and the U.S. National Nuclear Security Administration (NNSA) to show the extent of its reach within that community. The INMM has made more than five decades of contributions to the nuclear professions and global nuclear security, with historical ties going back to the U.S. Atomic Energy Commission (AEC), the U.S. Energy Research and Development Administration (ERDA) and, today, the U.S. Nuclear Security Enterprise (NSE) under the NNSA and the DOE. The INMM is also the ANSI Accredited Standards Development Organization (SDO) for ANSI Standards N-14 (*Packaging and Transportation of Radioactive and Non-Nuclear Hazardous Materials*), and N-15 (three standards – *SNM Control and Accounting Systems for Nuclear Power Plants; Measurement Control Program, NDA Measurement Control and Assurance*; and *Measurement Control Program, Nuclear Materials Analytical Chemistry Laboratory*).

The INNM's work aligns with the DOE's Science and Innovation Strategic Goal: *Maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity with clear leadership in strategic areas.* This goal speaks to the basic research being conducted at many of DOE's national laboratories, including those within the NSE.

The work of the Institute also aligns with the five NNSA's Strategic Goals:

- Reduce nuclear dangers;
- Manage the nuclear weapons stockpile and advance naval nuclear propulsion;
- Modernize the NNSA infrastructure;
- Strengthen the science, technology, and engineering base; and,
- Drive an integrated and effective Enterprise.

INMM's membership includes many of the highly qualified technical scientists and engineers who work in these facilities, and who share their research activities through venues such as the INMM Annual Meeting; various technical workshops held year round both in the United States and internationally; as well as in the INMM peer-reviewed *Journal for Nuclear Materials Management*, which is published four times a year.

The *JNMM* usually has several scholarly articles on scientific research and policy, and occasionally publishes special editions on topics of broad interest such as international safeguards and material, control and accountability (MC&A), which may have ten or more articles contributed by its membership.

The INMM has also focused in the past fifteen years on the next generation of scientists and engineers, sponsoring twelve student chapters at universities in the United States and two international chapters. Participation from these students has been growing at the Annual Meeting and workshops in recent years, with thirty-nine papers submitted for judging in 2013.

Promoting the Institute

Adjusting our strategies to respond to the bumps in the road will be a continuous process. Implementation of those strategies needs the participation of all of our Institute members. Each member has a sphere of influence and personal contacts that should be leveraged to promote the good work accomplished, and the value added created through our annual meeting and workshops. It is not unusual to feel overwhelmed in this environment, particularly when we are all dealing with issues in our work and the external events that complicate our world today. But, if we can work together to execute these strategies, including a common goal of promoting the Institute, we will be able to smooth out those bumps in the road, and contribute to making this a safer and more secure world.

This column is intended to serve as a forum to present and discuss current strategic issues impacting the Institute of Nuclear Materials Management in the furtherance of its mission. The views expressed by the author are not necessarily endorsed by the Institute, but are intended to stimulate and encourage JNMM *readers to actively participate in strategic discussions. Please provide your thoughts and ideas to the Institute's leadership on these and other issues of importance. With your feedback we hope to create an environment of open dialogue, addressing the critical uncertainties that lie ahead for the world, and identify the possible paths to the future based on those uncertainties that can be influenced by the Institute. Jack Jekowski can be contacted at jpjekowski@aol.com.*

Calendar

May 12–14, 2014
Third International Conference on Physics and Technology of Reactors and Applications
Tetouan, Morocco
Website:
www.gmtr-association.com/phytra3/

May 12–14, 2014
INMM Information Analysis Technologies, Techniques and Methods for Safeguards, Nonproliferation and Arms Control Verification
Portland Marriott Downtown Waterfront
Portland, Oregon USA

July 20–24, 2014
INMM 55th Annual Meeting
Atlanta Marriott Marquis
Atlanta, Georgia USA
Website:
www.inmm.org/AM55

August 24–28, 2014
8th International Conference on Isotopes and Expo
Hyatt Regency Hotel
Chicago, Illinois USA
Website:
www.8ici.org

January 12–14, 2015
INMM 29th Spent Fuel Seminar
Crystal Gateway Marriott Hotel
Arlington, Virginia USA
Website:
www.inmm.org

September 11–16, 2016
PATRAM 2016
Kobe Portopia Hotel
Kobe, Japan

Author Submission Guidelines

The *Journal of Nuclear Materials Management* is the official journal of the Institute of Nuclear Materials Management. It is a peer-reviewed, multidisciplinary journal that publishes articles on new developments, innovations, and trends in safeguards and management of nuclear materials. Specific areas of interest include facility operations, international safeguards, materials control and accountability, nonproliferation and arms control, packaging, transportation and disposition, and physical protection. *JNMM* also publishes book reviews, letters to the editor, and editorials.

Submission of Manuscripts: *JNMM* reviews papers for publication with the understanding that the work was not previously published and is not being reviewed for publication elsewhere. This restriction includes papers presented at the INMM Annual Meeting. Papers may be of any length. All papers must include an abstract.

The *Journal of Nuclear Materials* Management is an English-language publication. We encourage all authors to have their papers reviewed by editors or professional translators for proper English usage prior to submission.

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Submissions may be made via e-mail to Managing Editor Patricia Sullivan at psullivan@inmm.org. Submissions may also be made via by regular mail. Include one hardcopy and a CD with all files. These submissions should be directed to:

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- Tables, figures, and photographs in TIFF, JPEG, or GIF formats. Color is encouraged.
- Numbered references in the following format:
  1. Jones, F.T., and L. K. Chang. 1980. Article Title. *Journal* 47(No. 2): 112–118. 2. Jones, F.T. 1976. *Title of Book*, New York: McMillan Publishing.
- Author(s) biography

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Peer Review: Each paper is reviewed by at least one associate editor and by two or more reviewers. Papers are evaluated according to their relevance and significance to nuclear materials safeguards, degree to which they advance knowledge, quality of presentation, soundness of methodology, and appropriateness of conclusions.

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