

Public Interest Report

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President's Message 2

Global Approach to Biosecurity 3

China's Attraction to the Atom 6

The French Civilian Nuclear Industry
After the Roussely Report 15

Questions About
Nuclear Deterrence 24

2010 FAS Awards 26

Global Approach to Biosecurity

Nishal Mohan, director of the FAS Biosecurity Program, writes about dual use education, bridging the law enforcement community and academia, and a new global initiative.

Read more on page 3.

China's Attraction to the Atom

China's nuclear energy industry must confront some very real and very serious challenges. Yifei Zhang examines whether or not nuclear energy expansion is sustainable for the long term in China.

Read more on page 6.

French Civilian Nuclear Industry

The Roussely Report was a strategic review of the French civilian nuclear industry. Richard Cleary provides an assessment of the advantages and disadvantages of the report's recommendations.

Read more on page 15.

About FAS

The Federation of American Scientists (FAS), founded in 1945 as the Federation of Atomic Scientists by Manhattan Project Scientists, works to ensure that advances in science are used to build a secure, rewarding, environmentally sustainable future for all people by conducting research and advocacy on science public policy issues. FAS is a tax-exempt, tax deductible 501(c)3 organization.

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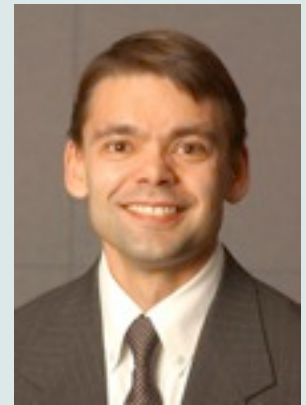
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PRESIDENT'S MESSAGE

Going Global



The world is becoming increasingly interdependent and interconnected. While FAS has always been concerned about international security—especially because of the geopolitical repercussions of weapons proliferation, this issue of the *PIR* illustrates the global reach of FAS. FAS's Biosecurity Program, described in the first article, has networked biologists and biosecurity professionals around the globe. As Dr. Nishal Mohan, the director of this program, explains, FAS has worked with academia, non-governmental organizations, and governmental agencies to create and provide a suite of educational materials and has advocated for responsible use of biological science and technologies. Also, this program has recently launched the Virtual Biosecurity Center, "a one-stop-shop" for information, news, and analysis on biosecurity.

Although the United States is still struggling to revive construction of nuclear power plants, the two insightful articles on China's nuclear industry and France's nuclear exports highlight two countries that have successfully used nuclear technology transfer from the United States. As Yifei Zhang, a graduate student at Georgetown University's School of Foreign Service, shows, the Chinese nuclear power program has grown significantly because of strong government financial support, little or no overt public opposition,

and competition among powerful state-owned companies. French nuclear exports, however, have recently stumbled. In that article, Richard Cleary of the American Enterprise Institute examines whether the reforms in the newly published Roussey Report will lift Team France out of its malaise.

The feature articles conclude with an iconoclastic challenge to nuclear deterrence, written by Ward Wilson, one of the most innovative thinkers on nuclear weapons policy. This issue ends by recapping FAS's Awards Dinner that celebrated the achievements of John Holdren and Barbara Pyle.

In the next issue, the editorial team will unveil a redesign. It will include even more articles from authors outside of FAS staff and will contain new features such as an interview with a prominent scientist, two differing views on an urgent security issue, and a book review.

As always, I am very grateful for the financial support from the *PIR*'s subscribers and FAS's members. FAS could not publish without you. **FAS**

By Nishal Mohan, Director of the Biosecurity Program at the Federation of American Scientists

What is biosecurity? Biosecurity includes measures taken to prevent and respond to the potential misuse, loss, and accidental or intentional use of natural or modified pathogens or toxins against humans, animals, or plants.

Introduction

For more than five years, the Federation of American Scientists (FAS) has been a leader in biosecurity outreach and education within academia, non-governmental and governmental organizations. The Biosecurity Program focuses on researching and advocating policies that balance science and security, prevent the misuse of research, promote public understanding of the real threats from biological weapons, and coordinate biosecurity efforts worldwide.

The Biosecurity Program takes a global approach to biosecurity.

Learn more about the program by visiting the website: <http://www.fas.org/programs/bio/index.html>. Follow the Biosecurity Blog for analysis and perspectives on current biosecurity issues: <http://www.fas.org/blog/bio/>.

Biosecurity Education

The biological research community continues to struggle to recognize that some of its work, although undertaken for legitimate reasons and beneficial ends, may have harmful applications. Biological research administrators, educators, researchers, and students are largely unaware of the emerging national and international security imperatives surrounding their research. Many do not appreciate the ramifications of laws and regulations governing laboratory operations and the treatment of dangerous pathogens or envision the potential misuse of academic research results, techniques, or facilities. Moreover, few are aware of the role they should perform in preventing the misuse or misappropriation of otherwise beneficial research to bioweapons applications.

For biosecurity measures to be effective and actually reduce the risk of biological agent misuse, the biology research community must be a) made aware that their research could be misused in whole or part, b) be engaged in policy making and the creation of guidelines, c) have a strong relationship with law enforcement, d) be aware of how to react to potential security issues, and e) be able to identify security holes. To develop effective recommendations, the biological research community must be involved in the creation of biosecurity regulations. The FAS dual use research training materials is raising awareness of these issues. Access the Case Studies in Dual Use Biological Research by visiting <http://www.fas.org/biosecurity/education/dualuse/index.html>.



This suite of educational training materials is commonly used within academia worldwide as a model on how to successfully implement dual use education. These materials are used internationally by scientists, students, the policy community, the public and by the Federal Bureau of Investigation (FBI) for their educational outreach initiatives.

As modern molecular biology techniques advance, so does the potential that beneficial research could be used for malicious purposes. FAS's case studies help define and raise awareness of the issues associated with dual use research and security in the laboratory. They include interviews with

researchers whose legitimate scientific work was questioned as being dual use research of concern; and provide a historical perspective on bioterrorism and research regulations. These case studies are applicable to a large number of students and scientists. The reconstruction of the 1918 influenza virus is perhaps the most widely known case of dual use research to date. Even within the scientific community, the publication of the 1918 influenza work ignited an intense debate about how to handle experiments that could pose a dual use concern.

The most recent case study addresses how scientists can improve community relations by taking a proactive role in addressing public concerns and increasing awareness of the dangers of biomedical research. This study is the first to address this issue and focuses on how non-scientists view dual use research while demonstrating that researchers have a moral responsibility to be aware of their dual use experiments. As a respected non-scientist, Susan Ehrlich, a former judge on the Arizona Court of Appeals and member of the National Science Advisory Board on Biosecurity (NSABB), was interviewed on the public's concerns about dual use research. It is imperative that researchers learn and adapt to new regulations for monitoring research, and be able to openly publish results.

The educational materials complement the ethics courses required for graduate students on federal training grants. Flexibility is the key to lowering barriers to instructors who wish to incorporate the material into their classes. The case studies are online and accessible worldwide during class or outside of the classroom.

What are dual use research and technology? Beneficial scientific technologies or research that have the potential to be misused for malicious purposes.

What's Next for this Series?

The next dual use case study will feature agricultural research and biosecurity issues. Currently, most of the attention given to biosecurity and bioterrorism is focused on the threat of human pathogens to human health and safety. However, in addition to these threats, attention should be paid to agricultural threats. With the increasing challenge of feeding a growing population, the safety and security of the food supply should be a top policy priority. Crops and livestock can be afflicted with a wide range of infectious diseases, including bacteria, viruses, fungi, parasites, oomycetes, and viroids that impact production and could potentially devastate whole economies. Detecting and controlling these diseases are a significant challenge for the agricultural industry worldwide.

With the lives and economies of the entire world at stake, a significant amount of research in the life sciences and biotechnology focuses on these pathogens and the technologies to control them. New research could overcome the battle against disease, increasing the availability and quality of foods and economies. However, this promise is accompanied by the potential to misuse scientific research

and biotechnology by malicious individuals or states to disrupt the agricultural industry for the purposes of terrorism, warfare or corporate sabotage. Look for this latest addition to the dual use case studies in 2011.

FAS is also working on visually appealing and interactive biosecurity educational materials specifically designed for the International Genetically Engineered Machine (iGEM) competition community and the emerging Do-It-Yourself Biology (DIY-Bio) community.

To improve international outreach, these educational materials have been translated into French, Mandarin and Russian. Translations into all UN languages should be available by the summer of 2011. The FAS Biosecurity Program staff is active worldwide, participating in dual use education and promoting the case studies.

Bridging the Law Enforcement Community with Academia

Biosecurity organizations often do not enlist the intelligence (IC) and law enforcement (LE) communities when producing reports and events, neglecting some of the most significant players in the field. The FAS Biosecurity Program believes that this is because the biosecurity community is either unaware of how to engage them or fear engaging them. This critical communication gap must be closed.

In the summer of 2007, FAS and the FBI partnered to address how best to bridge the gap between the FBI, LE and researchers in the scientific community? In collaboration with the American Association for the Advancement of Science (AAAS), thousands of academic scientific

researchers were surveyed on their views and interactions with LE. Previously, there was no systematic data on the attitudes of scientists on this issue. To obtain quantitative and qualitative information about the views of scientists at different career stages and in various disciplines, 1332 respondents were interviewed. The survey was voluntary with an option to submit responses anonymously to encourage candor. The results of the survey, "How Scientists View Law Enforcement" were published in the journal *Science Progress* (Hafer, N., Vos, C.J., et al (2008). *Science Progress*: December 22) (<http://www.scienceprogress.org/2008/12/science-and-law-enforcement/>).

The survey indicated a reluctance of scientists to discuss research and other issues specific to the scientific community with LE. Scientists are most comfortable explaining their work to those that demonstrate familiarity with scientific concepts, possibly because they are less concerned that their research will be misunderstood.

The release of the survey results provided an opportunity to inform the scientific community that LE agencies were interested in strengthening ties and understanding their points of view. Further, the survey report provided the groundwork for forming new agency protocols on handling interactions with the scientific community. This story was covered on National Public Radio's (NPR) Morning Edition on the morning of its release (<http://www.npr.org/templates/story/story.php?storyId=98577473>).

The responses were used to design a training video featuring scientists discussing their views on LE and their opinions on how to forge a productive relationship.

The video will raise awareness of the varying views law enforcement personnel are likely to encounter when interacting with the scientific community and to provoke discussion on how best to interact with scientists. It may also provide insight into best practices for coordinating contact between multiple agency units and individual academic institutions.

The consequences of allowing discord between LE and scientists to linger may affect public safety as criminal, terrorist, and national security challenges become increasingly technical, and close collaboration with the scientific community becomes ever more essential. Cooperation with all entities that play a significant role in biosecurity is crucial.

Global Approach to Biosecurity

FAS has created an expansive internet resource for biosecurity policy, bioterrorism information, biodefense publications and biodefense research. The FAS Biosecurity Program website includes a comprehensive library of biosecurity related legislation, executive orders, treaties, reports and links to biosecurity organizations. The main goal is to provide a platform for individual scientists, research institutions, the public, and the government to discuss

the best ways to minimize the threat of bioterrorism while maximizing the benefits of life science research. Additional resources include an interactive Biosafety Level 3 and 4 facilities map (the level of containment precautions required to isolate dangerous agents in an enclosed facility range from the lowest biosafety 1 to the highest level 4), an archive of publications and videos from the defunct Office of Technology Assessment, and biological threat agent fact sheets and resources.

One considerable challenge in biosecurity has yet to be addressed. There is a consensus among biosecurity experts globally about the need to do a better job at engaging the public, research community and government to successfully influence future biosecurity and public health preparedness policy. To meet this demand for better coordination and communication, the FAS Biosecurity Program has created a multi-organizational center for communities worldwide to share news and information, collaborate on best practices, and access reference materials to help counter the threat posed by the development or use of biological agents. This “one stop shop” for biosecurity news, information, calendar of events, educational resources, and collaboration tools is the first of its kind. Individuals from around

the world now have the most extensive array of biosecurity information and collaborations at their fingertips instead of spread out among numerous websites.

This global initiative is made possible through the collaboration of FAS with a network of U.S. and international leaders in biosecurity, science policy and the life sciences, including organizations like AAAS, the National Academy of Sciences (NAS), the Organisation for Economic Co-operation and Development (OECD), and other prominent groups committed to share their activities and educational materials.

This center presents an important opportunity to improve the state of biosecurity and public health preparedness, and the development of novel content and new media will be a centerpiece of these efforts. By improving communication in a subset of the security community internationally, the center can become a model for future collaborations and go beyond what is possible today. The Virtual Biosecurity Center launched on February 24, 2011. To learn more please visit: <http://virtualbiosecuritycenter.org/>.

To learn more about the FAS Biosecurity Program, please visit <http://www.fas.org/programs/bio/index.html>. **FAS**

Nishal Mohan is the director of the Biosecurity Program and his work focuses on biological weapons control, training and preparedness for WMD attacks, and the responsible use of science and technology.

“Cooperation with all entities that play a significant role in biosecurity is crucial.”



6 China's Attraction to the Atom

By Yifei Zhang of the Edmund A. Walsh School of Foreign Service at Georgetown University



“Predictions on nuclear energy in China have often seemed hyped, leading to exaggeration and disappointment. Observers should ask: Is nuclear energy expansion in China sustainable in the long term, or momentarily inflated and likely to dissipate?”



Nuclear Optimism in China

In late 2006, Toshiba Electric purchased American nuclear giant Westinghouse Electric Corporation for more than \$5 billion.¹ At the time, this appeared to signal the end of America's leadership in nuclear energy. For a moment in 2010, new developments hinted at a reinvigoration of the U.S. nuclear energy industry. On February 16, 2010, the Obama administration approved conditional federal loan guarantees of \$8.3 billion for nuclear power plant construction, in part to assist a project for two innovative Westinghouse reactors in Georgia.²

However, Westinghouse's future is bound to decisions unfolding on the other side of the Pacific. Nine months before its Georgia contract, China's State Council's National Development and Reform Commission (NDRC) approved Westinghouse to supply the first four of these new reactors to sites in the Shandong and Zhejiang provinces.³ According to the NDRC and Westinghouse, this new Generation III+ advanced passive 1000 MWe reactor (the AP1000),⁴ would serve as a template for greater developments in China's future nuclear energy infrastructure.⁵

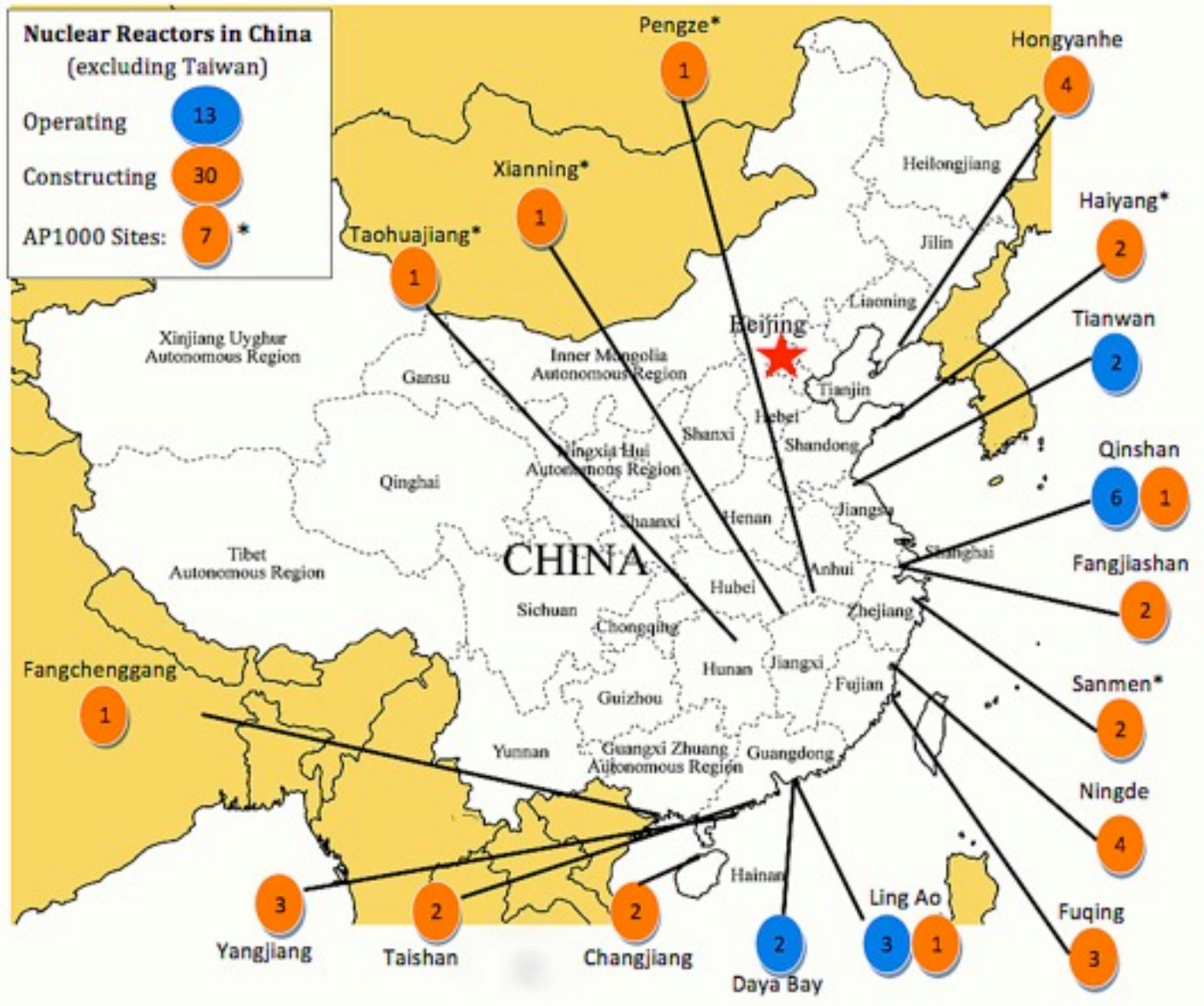
In January 2011, China had 13 operational nuclear reactors. During 2011, potentially more than 30 will be under construction, with many more planned for the future.⁶ By March 2010, estimates had China aiming for at least 4 percent of its total installed power capacity to come from nuclear generation by 2020 (70-80 GWe of operating installed capacity), up from a paltry 1.9 percent (9 GWe)⁷. For the past three years, these estimates have been pushed upward. Before 2008, the NDRC's 2020 targets were only 40 GWe.⁸ By late 2010, remarks made by Geng Zhicheng, a senior researcher at

the NDRC, indicated that 2020 targets might rise to 114 GWe, or 7 percent of total capacity.⁹ In January 2011, the State Council Research Office cautioned to stay within the 70 GWe target.¹⁰ In the first 10 years of this century, China constructed roughly one reactor each year. This rate was far lower than that achieved historically by the United States and France, which completed 3-4 reactors per year during their peak construction periods.¹¹ To meet the 70 GWe target, China would need to build 7 - 8 reactors annually, double

the historic rates achieved by America and France.¹² Past predictions on nuclear energy in China have often seemed hyped, leading to exaggeration and disappointment. Observers should ask: is nuclear energy expansion in China sustainable in the long term, or momentarily inflated, and likely to dissipate? Naysayers point to a large number of very real and very serious challenges that China's nuclear energy industry must confront.

First, nuclear energy faces fierce competition from renewable energies,

natural gas, and coal, which continues to dominate. Second, even with a coherent development plan, the implementation of China's nuclear energy development faces numerous political challenges. Third, popular mistrust and opposition to nuclear energy could emerge in China, as it has in many other countries, holding back expansion long before it could really lead to major changes. Fourth, pessimistic views of nuclear growth in China suggest that nuclear technologies remain deficient compared to innovations occurring elsewhere.



8 China's Attraction to the Atom (con'd)

Although these arguments have some merit and a degree of persuasive power, this article instead argues that nuclear energy in China will continue to *grow and expand*. Varied forces account for this inevitable expansion. First, nuclear energy development in China enjoys government support and faces few of the challenges it does in other political, social, or economic environments. China is perhaps uniquely positioned for nuclear expansion. Second, as time passes, domestic drivers will make nuclear power *increasingly attractive* to China, not less so. Third, China's nuclear reactors display a higher degree of sophistication through the successful absorption and implementation of foreign technologies.

Government, Nuclear Enterprises, and the Public

China's political system is not the highly centralized, efficient, authoritarian model that many believe. The government faces numerous problems to enhancing capacity. These impediments include slow consensual decision making, poor local execution of central policy, opposition between regional and central authorities, and extensive corruption. As a result, some have labeled China's political system "fragmented authoritarianism," a restricted authoritarianism with factional competition.¹³ In recent decades, these characteristics have been reinforced by the economic reforms, political reorganizations, and privatizations that occurred under Deng Xiaoping and successive leaders. No doubt, these effects have carried into key sectors such as energy.

Today the People's Republic of China has no Ministry of Energy (it was dismantled in 1993).¹⁴ Instead, China's leaders often direct and formulate energy policy through ad hoc working groups. Preposterous and alarming as it may appear, this patchwork system runs against the popular image of a strategic thinking, monolithic Chinese government cunningly conceptualizing five year plans.

Does this mean that China's government grasps at different policy

directions, with no broad energy strategy? Fragmented authoritarianism has been a condition across various sectors of government, not energy alone. Economic success has occurred in recent decades in spite of it, perhaps even because of it. Although no formal ministerial level group specifically represents energy, the roles that such a ministry would take up are divided in non-confrontational and non-overlapping ways across the State Council's different subgroups. These subgroups administer different responsibilities.

Organizations like the NDRC and its subordinates (the National Energy Agency) take a leading role in energy policy making. Ad hoc groups such as the National Energy Leading Group, composed of Premier Wen Jiabao and 21 of the State Council's executive ministerial heads, deliberate on and crafts energy policy and strategy.¹⁵ The Chinese government certainly has long and short term goals for nuclear energy. Apart from the expansion noted above, these goals include a fully internalized nuclear fuel cycle and acquisition of advanced nuclear technologies.¹⁶ Past guidelines have highlighted a course to identify and standardize modern reactor types, ultimately moving towards the adoption of fast and high temperature neutron reactors and breeder reactors, with fusion plants as a long-term objective.¹⁷

The government's relationship with large energy corporations reflects its decentralized decision making. Powerful state owned enterprises (SOEs) dominate China's nuclear power industry. What exists is not a traditional government monopoly, but a collection of national champions that operate under conditions of limited competition within government ownership. All Chinese SOEs are part of the State-owned Assets Supervision and Administration Commission of the State Council (SASAC); the major corporations and subsidiaries of China's nuclear energy industry are no different.¹⁸ Chinese nuclear SOEs construct plants and sign contracts largely without central government input until the end. They also hold

complementary roles. The China National Nuclear Corporation (CNNC) manages most of China's civilian nuclear programs, including the fuel cycle, uranium mining, waste disposal, and overall investment in nuclear power.¹⁹ The China Nuclear Engineering and Construction Corporation (CNEC) constructs nuclear power stations. The State Nuclear Power Technology Corporation (SNPTC) coordinates purchases of advanced foreign technology and domestic research development. The China Guangdong Nuclear Power Corporation (CGNPC) manages many of the country's nuclear stations and new nuclear development in the south.²⁰

Nuclear SOEs receive significant financial backing from the central government.²¹ While the nuclear sector faces competition from other energy industries, it does not necessarily face adverse conditions in the allocation of central funding.²² The close link between nuclear SOEs and government monetary support can overcome the hardships that nuclear energy development faces in other countries. The financial risk, the high initial investment cost, is one reason nuclear power plants have been unpopular elsewhere. The substitution of costs through government support alleviates that risk. The CNNC has been so confident of government and private financial backing that it claims to invest \$120 billion on its own nuclear energy projects by 2020.²³ Setting broad targets, offering large sums for financial assistance, and leaving micromanagement to SOEs may be the *emerging pattern* in managing nuclear energy development in China.

Political power in China, however fragmented, remains the exclusive domain of the Communist Party, which rules through an oligarchic one party system that can stifle opposition. In a one party system, the "not in my backyard" mentality that afflicts publics elsewhere can be defeated through illiberal tools that suppress or marginalize dissenting voices. For example, the opposition to construction of China's massive hydroelectric dams, an economically demanding energy

project with more demonstrable ill effects than nuclear power stations, was easily blocked.

While some have claimed that there are noticeable and growing voices of dissent to nuclear energy in China,²⁴ this has been specific to Hong Kong.²⁵ The popular sentiments against nuclear energy and the suspicion that exists in America does not prevail with the public or academia in China. No organized opposition to new nuclear construction has emerged like the criticism to Westinghouse's new AP1000 in the United States.²⁶ While the NDRC has wholeheartedly adopted this novel design as *the standard* of all future inland reactor projects, the AP1000 system continues to undergo review in the United States by the Nuclear Regulatory Commission. Overall, the combination of limited public opposition to nuclear power and government support for and delegation to nuclear SOEs has created unique socio-political conditions that favor nuclear energy development.

Nuclear Energy in China's Imperfect Energy Future

The vast majority of China's operational nuclear power plants exist along the southeastern coast in the relatively wealthy and developed provinces of Jiangsu, Zhejiang, and Guangdong. Until very recently, interior provinces have not seen much nuclear reactor construction. Westinghouse's AP1000 reactors may represent the first step in a growing trend focusing on moving construction further inland. The Chinese interior is an important consideration for nuclear energy because it is in these areas that social unrest, particularly the kind associated with environmental degradation, is the

most severe.

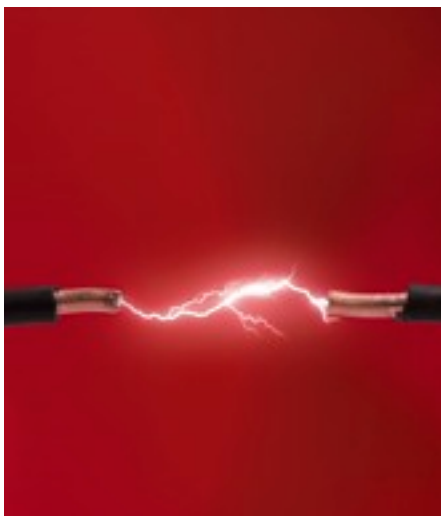
Much of this grievance and anger is related to the near ubiquitous use of coal-fired power plants and the damage done to the air, land, and water systems.²⁷ In China, coal remains king. Nowhere is this more pronounced than in the poor and disadvantaged populations of the country's vast interior. Coal continues to be attractive in these areas because of its low price and availability. Coal mining and energy intensive heavy industries like steel making, rely on coal and are promoted by the state because they employ such large numbers. Some predictions claim that by 2050, 300 million migrant workers will move to cities, heightening energy security.²⁸ In developing Asia, new urban dwellers consume three times as much energy as their peers in the countryside.²⁹ For the foreseeable future, this insatiable and mutually reinforcing demand for energy, urban life, and work appears to be unavoidable. To date, coal has been the primary answer to this dilemma.³⁰

Distressingly, some projections now raise the prospect of coal depletion and an arrival of "peak coal" in China around 2020.³¹ A continued reliance on coal will exacerbate energy shortages, perpetuate tragedies in local communities through lethal mining accidents, lead to further price gouging by coal barons, and cause continued domestic instability and international anger due to pollution. While China could offset some of these problems with a greater reliance on oil and natural gas, or even greater importation of coal, these options only reinforce already powerful and growing insecurities over foreign dependence. Alternative sources of energy like wind or solar power are geographically demanding even if increasing economies of scale

work to drive down costs. The restrictions on the location of and amount of land required to build renewable energy facilities limit their practicality even if the highly populated central areas of China grew significantly richer. Greater efficiencies must emerge in power transmission over vast distances if alternative energy options are to become more attractive. Wind and solar energies will likely begin to make major impacts in China only after mid-century. In terms of hydroelectricity, there are only so many rivers China can tame. Further hydroelectric expansion will trigger international anxieties and animosity as China alters transnational riparian systems and affects the downriver populations reliant on them for their livelihoods.

Although it is unlikely that nuclear power can substitute for the couple of thousand coal plants powering Chinese cities and industries, it can alleviate concerns about import dependence and still provide the high outputs necessary for major metropolitan areas.³² Nuclear power is unquestionably cleaner than hydrocarbons, and will remain significant in long-term solutions to energy problems in China. Increasing prices for oil and gas will make nuclear energy more competitive,³³ and government investment and subsidies could deliver it to relatively less wealthy inland areas. New reactor types, such as the AP1000 defeat previous geographic restrictions and will make nuclear energy far more accessible to these inland zones. China may never become as reliant on nuclear power as France or even the United States does (at least not for a long time), but appeal will be durable because of pressures from growing energy demand, internal instability, and energy insecurity.

10 China's Attraction to the Atom (con'd)



Advanced Nuclear Energy Technologies in China

Can China be a nuclear energy leader if it does not build innovative nuclear technologies? In the past, it has done an excellent job of buying components abroad, paying for foreign designs, and remaining reliant on foreign technologies.³⁴ This is changing. China is building more reactor components domestically. In the process of acquiring and installing foreign designs, Chinese nuclear companies are learning to build these technologies independently or with adaptations. A comparison to how other Chinese strategic industries have operated is helpful. As with solar, wind, and high speed rail technologies,³⁵ the government first enticed foreign companies to bring their technologies to China by offering market access. Chinese companies then duplicated and modified these technologies over time. In later stages, they aimed to gain a stronger foothold domestically and moved to target the developing world and broader international markets.³⁶

This same process is occurring with China's nuclear SOEs. The China Guangdong Nuclear Power Corporation (CGNPC) and the State Nuclear Power Technology Corporation (SNPTC) developed the CPR1000 (China Pressurized Water Reactor of 1000 MWe) by modifying an older Areva

design.³⁷ Fifteen of these Generation II+ units, the majority of current projects in China, are under construction.³⁸ China can build components for these reactors without foreign assistance (in the near future 90 percent of the reactor and its subsystems will be built in China).³⁹ CGNPC is also working to acquire the rights to build the reactor without any intellectual obligation to Areva, and is moving forward with further iterations of the design. The new ACPR1000 may be ready for export as early as 2013.⁴⁰ Meanwhile, the Shanghai Nuclear Engineering Research & Design Institute (SNPTC) and Westinghouse are developing even more advanced and larger designs of the Generation III+ AP1000,⁴¹ with the potential capacity of 1400 MWe (CAP1400) or even larger 1700 MWe (CAP1700) as a general standard for inland provinces.⁴² There are strong indications that Chinese SOEs intend to eventually sell these designs overseas to developing markets, competing with North American, Japanese, and European companies.⁴³

China is already an important player in newly-emerging passively-safe reactor technologies.⁴⁴ Safe operation of older reactors is costly, requiring robust containment structures, time intensive training of personnel, and precise controls maintained by complex mechanical systems. Many new designs of the Generation III+ designation overcome older deficiencies by combining robust active and passive water cooling systems (Mitsubishi's APWR), removing water as a coolant (the South African Pebble Bed Modular Reactor), and adding more active safety systems (Areva's EPR, which also includes a core catcher system).⁴⁵ Generation IV reactors are expected after 2030, incorporating some combination of novel materials, innovative coolants, unique fuels, proliferation resistance, higher temperatures, hydrogen generation, and lower cost. The China Atomic Energy Authority and Ministry of Science and Technology are partnering with foreign

agencies in the Gen IV International Forum on two of six Gen IV designs - the Very-High-Temperature Reactor and the Sodium-Cooled Fast Reactor. These are also the only categories under consideration by the U.S. Department of Energy.⁴⁶

The nuclear industry is trending toward designing and developing smaller reactors even as it builds and improves the designs of larger ones. China could emerge as a major builder in the future of small or modular reactors⁴⁷ through the innovative Pebble Bed Reactor (PBR). Pebble bed nuclear technology is known for its unique reactor core consisting of a containment vessel housing thousands of individual balls of uranium wrapped in layers of silicon carbide, ceramic material, and finally graphite.⁴⁸ Coatings around the uranium have a melting point higher than the reactor temperature ceiling, allowing for a design which is potentially physically resistant to meltdown. Since the reactor uses no water for cooling or steam, it instead relies on inert gases such as helium or nitrogen to drive turbines; steam explosions become impossible, and the use of inert gas reduces the risk of fire.⁴⁹ The CNNC completed construction of a working 200 MWe test bed in 2007 at Tsinghua University in Beijing (the HTR-10).⁵⁰ Although PBR designs exist elsewhere in the world, and even may be more sophisticated, as of early 2011 China operates the only PBR in the world.⁵¹

While the previous examples might be unconvincing, one must consider that the nuclear industry in China is doing an excellent job of enticing foreign interest. Even with limited domestic reactor innovation, attracting a high degree of foreign interest means that the Chinese market will remain within the calculations and considerations of those involved with the most innovative nuclear technologies. International nuclear energy companies will arrive in China with the hope of doing business, and transfers of technology will be a natural consequence.

A Bright and Perilous Road Ahead?

China will likely continue as an attractive country to sell these technologies because its political environment supports nuclear energy. The communist government and China's nuclear corporations are best seen as parts of a singular mechanism. While the first limits civilian opposition to nuclear growth and supports a domestic nuclear industry, the latter pushes forward technical advances. Reactors are being built in many other places around the world, but nowhere else offers a similar scope of expansion. This article has attempted to show that the appeal of nuclear energy in China will continue to grow due to powerful internal drivers. China's nuclear energy growth, unlike the predications given by nuclear pessimists, will remain persistent.

Objects moving at great speeds are especially difficult to control. Aside from feeding China's nuclear appetite by selling reactors to Chinese corporations, the United States should leverage its experience and sophistication in operating and protecting nuclear power plants. The concern over safety and security in and around China's nuclear plants cannot be ignored, no matter how numerous or how advanced Chinese reactors become. As China surges ahead with nuclear energy, nuclear incidents have to date been almost unheard of, or at least, underreported. However, Chinese nuclear infrastructure, as with all nuclear infrastructure, is not immune to hazards. Last May and October, small leaks occurred at the Daya Bay Nuclear Power Plant in Guangdong.⁵²

Being a leader can mean many things. A nuclear leader might be the country with the most nuclear plants, it might

also be the country building the most nuclear plants, or alternatively the country developing the most innovative nuclear technologies.

Being a nuclear leader should also be synonymous with nuclear responsibility. The United States has an opportunity to share experiences and teach the complexities of nuclear safety and security.⁵³ After all, best practices and cultures are much more difficult to duplicate and adopt than objects. In protecting nuclear sites, the transportation of nuclear materials, quick response and general management, and in safety training, the United States is still the unquestioned world nuclear leader. This is one field where China still lags far behind America, but it is a field in which Americans should readily embrace parity. **FAS**

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"Objects moving at great speeds are especially difficult to control... The concern over safety and security in and around China's nuclear plants cannot be ignored."

12 China's Attraction to the Atom (con'd)

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The article noted that China's central news network, the CCTV, claimed that "the country now had enough fuel to last up to 70 years and the new technology could yield enough to last for 3,000 years."
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18. Major nuclear SOEs include the State Nuclear Power Technology Corporation (SNPTC), China National Nuclear Corporation (CNNC), China Guangdong Nuclear Power Corporation (CGNPC), China Nuclear Engineering and Construction Corporation (CNEC), and the China Power Investment Corporation (CPI).
19. It is what remains of the original Ministry of Nuclear Industry, which coordinated all things nuclear until the late 1980s. Unsurprisingly, it also has a role in China's military nuclear programs.
20. Although CGNPC is seen as playing an increasingly independent role from CNNC, this may be an inaccurate assessment. 45% of CGNPC is owned by CNNC, most processes between nuclear SOEs are opaque, and most SOEs likely cannot operate without some support from CNNC. The CNEC handles all of China's nuclear station construction. The SCPTC coordinates all purchases of advanced foreign technology.
21. Xu, pp 85, 89-93.
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23. World Nuclear Association, *Nuclear Power in China* (Oct 12 2010), p 2.
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By Richard Cleary, Research Assistant at the American Enterprise Institute

Introduction

On Sunday, February 21, 2011, the French Council of Nuclear Policy met to discuss the recommendations of the Roussely Report, a strategic review of the French civilian nuclear industry completed in June 2010.¹ The Roussely Report was intended to chart a corrective course for “Equipe France,” a group of Paris-based corporations involved in the export of nuclear expertise and technology.² Although the report is exemplary in many respects, it has one fundamental weakness: its assumption that, when multiple French nuclear corporations express interest in the same contract, they should join together for a shared bid. In the short-term, this vision of a unified, integrated French nuclear export offer deprives individual French civilian nuclear corporations of flexibility, likely sacrificing competitiveness.

Commissioned by President Nicolas Sarkozy and chaired by former CEO of Electricité de France (EDF) François Roussely, the Roussely Report was high-profile and high-stakes. The report was greatly anticipated, and its potential contents became a point of lively discussion in the months leading to the July 2010 release of its 23-page summary.³ Beyond proposing the integrated French bid mentioned above, the report clarifies the roles of important industrial actors and explores ways to increase coordination. The Roussely Report provides a frank and sweeping assessment of the structure and strategy of the French nuclear system, advising a more centralized and consolidated export model. As indicated above, however, in a highly competitive global nuclear energy market, it is unclear whether a unitary French bid, an “Equipe France,” stands the best chance of success.

The Roussely Report - and French nuclear export strategy generally - is best understood in light of the failed December 2009 bid by a French consortium for a \$20 billion contract for nuclear reactor construction in the United Arab Emirates (U.A.E.). The bid offers clear “lessons learned,” illustrating the strengths and



weaknesses of the French nuclear export industry as well as the challenges that will face future French nuclear bids abroad. First, the bid highlighted the difficulty of overcoming the track record of Areva’s Evolutionary Pressurized Reactor (EPR), which includes cost overruns and delays at construction sites. Second, the Emirates competition affirmed Electricité de France’s strong international reputation for its project management and operation of the nuclear reactor fleet within France. Third, the U.A.E. bid exposed a lack of coordination among French corporations as well as the absence of clearly defined roles for French nuclear companies in export markets. Finally, the success of the South Korean nuclear consortium was a reminder of the stiff competition French nuclear corporations face worldwide.

This article explores the advantages and disadvantages of the Roussely Report’s vision of an “Equipe France” competing

for civilian nuclear contracts abroad, and assesses whether the report’s recommendations will re-invigorate the French nuclear export industry or hinder its progress.

Overview: “Equipe France”

The Roussely Commission was charged with reviewing a sector which, despite its recent struggles, had an impressive record of innovation and leadership. From the discoveries of Henri Becquerel and Marie and Pierre Curie to the decision in the 1970s to turn to *le nucléaire* for energy independence, France has prided itself on its role in developing and advancing civilian nuclear energy.

Today, French companies operate 58 nuclear reactors within France and perform the gamut of ‘fuel cycle’ operations (the processes involved in the fabrication and recycling of nuclear fuel).⁴ Nuclear energy has had wide-ranging benefits for France, yielding low electricity prices, producing low levels of carbon,

16 The French Civilian Nuclear Industry (con'd)

and employing significant numbers (~200,000) of French citizens.⁵ The major players in France's nuclear system, Areva and Electricité de France, trace their roots to the years following World War II, when the state consolidated resources in Electricité de France (EDF), the national utility, and the Commissariat à l'Énergie Atomique (CEA). EDF is today the largest utility in the world (in terms of electricity produced and number of customers), with holdings in Europe and beyond. The CEA conducts nuclear research and is the principal stakeholder in .0Areva, the corporation formed in 2001 from the merger of two French companies, one specializing in reactor design and construction and the other in fuel cycle activities. Areva and EDF have enjoyed a strong collaborative relationship within France, providing complementary functions. While Areva has designed, constructed and provided certain upkeep functions for reactors, EDF has served as the architect-assembler (the project manager for reactor construction) and operator of the French nuclear reactor fleet.⁶ This clear division of competencies was re-asserted in the Roussey Report as the working model within France and, significantly, as the preferred method for cooperation abroad between EDF and Areva.

In recent years, the French nuclear sector has looked increasingly to foreign markets for growth. In 2004, the French congress re-classified EDF, making it a Société Anonyme (SA). With this new legal title, EDF could finally open its coffers to foreign investors and expand its offerings beyond electricity. The 2004 law also meant that, per European Commission regulation, EDF would no longer be the sole provider of electricity within France, creating opportunities for other energy providers.⁷ Although EDF had international holdings before becoming an SA, the 2004 law meant that it would look even more toward foreign markets, as its role within France was pared back. Areva, intended from the start to be an international player, has significant holdings abroad as well.⁸

The French state remains tied to EDF and Areva, holding majority shares in each company.⁹ French political involvement goes beyond this financial stake, however: for Paris, the sensitivity of nuclear technology coupled with the strategic value of cooperation abroad makes the nuclear sector a critical one. President Nicolas Sarkozy has had a visible role in its promotion around the world and coordination at home, calling for the Roussey Report and playing an important part in the ill-fated bid of a consortium of French civilian nuclear companies in the U.A.E.

The U.A.E. Bid

The French nuclear bid in the Emirates is an important case study, casting light upon the strengths and weaknesses of the individual actors of the French nuclear system as well as the unitary export model. For the first time, an exclusively French consortium was created for the purpose of selling Areva's 3rd generation EPR. The U.A.E. case offers lessons on a range of issues, including the weaknesses of the EPR, EDF's strong international reputation, the reasons for dissent and discord within "Equipe France," and the quality of French nuclear companies' opponents in foreign export markets. The French experience in the Emirates also confirmed that political support is valuable, if not determinative, in securing civilian nuclear contracts abroad. Although it is dangerous to extrapolate from any single bid, the experience of "Equipe France" in the U.A.E. confirmed some disconcerting (if also correctible) trends within the French nuclear export industry.

The prospect of a French sale of nuclear technology and expertise to the U.A.E. dates to Sarkozy's visit to Abu Dhabi in January 2008. Sarkozy often broached the prospect of bilateral nuclear cooperation during these visits, and significant diplomatic effort was directed toward North Africa and the Middle East. In the U.A.E., Sarkozy's visit included the signing of a bilateral nuclear cooperation agreement, which coincided with the announcement of a

French consortium's bid for a lucrative contract to build the Emirates' first nuclear reactors.¹⁰ The consortium would be composed of Areva, GDF Suez and Total; EDF, noticeably absent from the initial bid, was unwilling to depart from a strategy eschewing nuclear investment in the Emirates. In contrast, Areva decided to pursue the contract only after political overtures had been made.¹¹ In the words of Jean-Pierre Hauet, "Areva found itself in the heart of a project which was off to a good start" despite earlier indifference about a bid in the U.A.E.¹²

The close political relationship (and, since 1997, formalized "strategic partnership") between France and the U.A.E. may have played a part in Areva's optimism about the nuclear bid.¹³ Franco-Emirati collaboration was longstanding and deepening in defense, education, and culture. In the energy domain, consortium members Total and GDF Suez were active in the Emirates' oil and gas industry. Perhaps most important, French political support for the nuclear deal was consistent. Nicolas Sarkozy and his administration took a keen interest in the advancement of this and other "strategic" deals, assigning Claude Guéant, Secretary-General of the Elysée, to coordinate and promote the bid from his "war room."¹⁴ Guéant and his team lobbied on behalf of the French nuclear bid while also working to ensure that the French pitch was coordinated and well-prepared.¹⁵

Sarkozy's personal support for the bid did not end with his January 2008 visit. In May 2009, Sarkozy returned to the U.A.E. at the head of a star-studded delegation, accompanied by Minister of Foreign and European Affairs Bernard Kouchner, Minister of Defense Hervé Morin and Economic Minister Christine Lagarde.¹⁶ Although Sarkozy's second visit to the Emirates was ostensibly for the purpose of inaugurating a French military base overlooking the Strait of Hormuz, it had the added advantage of bolstering the French nuclear bid. This political support was timely, for Emirati

decision-makers had begun to voice their preference for EDF to join Areva, GDF Suez and Total in the French consortium. EDF's extensive track record as architect-assembler (the project manager for the construction of nuclear reactors) and reactor operator was attractive to Emirati decision-makers.¹⁷ EDF announced its decision to join the French consortium during Sarkozy's visit to the Emirates, reportedly after the French President had been asked by U.A.E. leadership to bring EDF into the French consortium.¹⁸

Sarkozy's efforts were met in kind by the South Korean government, on behalf of a consortium by the Korean Electric Power Corporation (KEPCO), which quickly emerged as the principal rival of "Team France." Korean political authorities oversaw, streamlined and promoted the KEPCO-led bid. According to diplomat Han Seung-soo, the Korean consortium's proposal included sharing South Korean "information technology and leading-edge capabilities" with the U.A.E.¹⁹ President Lee Myung-Bak, like Sarkozy, was reportedly involved. Lee would later describe the Korean consortium's successful bid as a "heaven-sent national fortune."²⁰

In Paris, more events were unfolding that would affect "Team France." EDF replaced CEO Pierre Gadonneix with Henri Proglio in September 2009. The change signaled a move toward a corporate management style that more closely resembled a conventional private sector model.²¹ Proglio's public criticism of Areva for its involvement at every stage of the fuel cycle and his statement that EDF should take the lead in the French nuclear sector set off a public rivalry between EDF and Areva.²² A crisis erupted regarding the delayed

delivery of spent nuclear fuel from EDF to Areva, with each firm blaming the other, and rumors circulated of a personal animus between Proglio and Areva CEO Anne Lauvergeon.²³ In January 2010, Prime Minister François Fillon invited Proglio and Lauvergeon to his residence to settle the dispute.²⁴ These incidents reflected the challenges of coordination that "Team France" would face.

Far from the swirling intrigue of Paris, the Emirates Nuclear Energy Corporation (ENEC) had been charged with choosing among the competing offers.²⁵ ENEC's evaluation of the French bid would turn in large part on its assessment of the EPR, the controversial 3rd-generation model engineered by Areva and German industrial powerhouse Siemens.²⁶ The EPR is intended to be the safest, most efficient and most secure reactor in the world. However, delays and cost overruns at EPR construction sites at Olkiluoto, Finland and Flamanville, France raised questions about whether the EPR could be constructed on schedule and at cost.²⁷ A joint letter produced by French, Finnish and British authorities regarding the "interconnectivity between the control and safety systems" of the EPR confirmed that the new design still needed refinement.²⁸ Further, EDF's absence from the initial consortium combined with Areva's limited experience in project management weakened the French bid.²⁹ Making matters worse, the Korean team was reported to have offered reactors at a lower price than that of its French competitor.³⁰ And, although KEPCO proposed a modified reactor design to meet the high standards of safety and security demanded by Emirati authorities, it had a track record of

building reactors, albeit simpler ones, on time and at a low cost.³¹ The French experience in the U.A.E. contract competition, although not the sole precipitating factor in the recommendations of the Roussely Report, was highly influential. The most positive lesson of the U.A.E. deal was that EDF enjoyed a positive reputation internationally: otherwise, the deal was a harsh encounter with a highly competitive bidding process. Perhaps unsurprisingly, the rejection of the French bid underlined the negative effect of questions regarding the EPR's cost and deliverability. Similarly, the public disputes between EDF and Areva had undermined the French proposal, calling into question the consortium's ability to cooperate. When the extensive efforts of the Elysée were met in kind by the South Korean government, the limitations of political support became evident. In sum, François Roussely and his committee would have much to review.

The Roussely Report

The December 2009 decision in the U.A.E. was preceded by an announcement from the Elysée: a comprehensive review of the French domestic nuclear system would be undertaken by a commission headed by former EDF President François Roussely.³² The report was highly anticipated, and its potential contents became a point of lively discussion in the months leading to the July 2010 release of its 23-page summary.³³ The Roussely Report addresses major points of controversy, such as the U.A.E. deal, the roles of EDF and Areva, issues of coordination and the place of the Elysée. Calling for "adaptation," the report identifies two overarching objectives: the revitalization of France's



18 The French Civilian Nuclear Industry (con'd)



domestic nuclear system and building a substantial presence in an expanding international nuclear market.³⁴

The report outlines a set of immediate recommendations along with a longer list of strategic ones. The most urgent priorities are the completion of the Olkiluoto and Flamanville projects with the least delay possible. On the other hand, the report suggests delaying the construction of the second proposed EPR in France (at Penly) until the lessons of the Olkiluoto and Flamanville projects can be assessed and internalized. The problems at these sites were attributed only in part to the design of the EPR, perhaps implying that the architect-assemblers (Areva for the EPR in Finland and EDF for the one in France) were responsible as well.³⁵

The Roussely Report also calls for a more intimate relationship between EDF and Areva in light of their recent tension.³⁶ This partnership would include clearly defined roles, with EDF to be “within France and abroad, the architect-assembler of Equipe France” in spite of the difficulties at its Flamanville site.³⁷ Areva, however, would not emerge intact, as the report outlines a spin-off arrangement for the corporation’s mining activities. The mining consortium proposal in the Roussely Report was adopted by the Council of Nuclear Policy in its February 2011 meeting. Areva will be a majority stakeholder in the consortium, presumably with EDF to have a role as well.³⁸

The Roussely Report provides more recommendations regarding “Equipe France” and the export market. First, Areva would continue to develop reactors to sell alongside the EPR.³⁹ Second, when venturing beyond the métropole (mainland France), French civilian nuclear corporations should be bound in “an industrial structure dedicated to exports.”⁴⁰ The report also calls for a stronger, more centralized political presence, namely “either ... a Minister of Energy or... a Secretariat General of Energy attached to the Presidency” to support and coordinate bids.⁴¹

Beyond its structural recommendations, the Roussely Report emphasizes a simple but important concept, that the track record of civilian nuclear companies within France impacts their sales abroad. French competency in recycling, its high standards in safety and security, and the planned permanent waste depository are important, as is the efficiency of the fleet of French reactors. Continued research and development, including the ASTRID breeder reactor, will be critical.⁴² As Jacques Figuet, French nuclear attaché to the United States, observed about reactors at Penly and Flamanville: “they are a showcase, but they are also today a reality.”⁴³

Although the Roussely Report is critical of the French nuclear industry as a whole, its criticisms fall particularly harshly on Areva. The report’s affirmation of EDF as architect-assembler, in spite of the issues at EDF’s Flamanville site, amounts to a rejection of Areva’s management of the Olkiluoto EPR. Similarly, the mining consortium and emphasis on security of supply (which is set to materialize in a long-term nuclear fuel deal between EDF and Areva) will likely work to EDF’s benefit at Areva’s expense. If fuel prices increase, as is expected, Areva will be bound to sell at a set, lower price to its French colleague, a significant blow to the world’s top uranium mining company. Still, although the report favors EDF, it does not cut EDF’s ties with Areva in the export market. In fact, the Roussely

Commission deepens the commitment to an integrated French bid, proposing a “strategic partnership” between the two corporations as well as a formalized structure for joint work abroad.

Conclusion

“Equipe France” faces a daunting international landscape as it looks to the future. Korean, Russian, American and Japanese companies will ensure competition in markets in North America, Europe and, the region in which the most growth is expected, Asia.⁴⁴ Against this backdrop, the Roussely Report identifies a number of weaknesses in the French nuclear export offer. Although certain weaknesses relate to the definition of roles and coordination among corporations, both quickly correctable through the measures proposed by the Roussely Report, others are more fundamental. The report’s commitment to a unified and consolidated French nuclear export industry therefore entails considerable risks.

“Equipe France” will face significant challenges in the coming years due to questions about the 3rd generation EPR’s deliverability, cost and operation. Although a comparison of construction time at the Olkiluoto, Flamanville and Taishan (China) sites demonstrates a learning curve (and compares favorably with average construction times during France’s initial expansion of its nuclear fleet), the EPR will be a “tough sell” until the Olkiluoto and Flamanville reactors are completed and online.⁴⁵ And, as Professor Jacques Percebois observes, although the EPR’s size (1650 megawatts) and sophistication (e.g. advanced safety and security measures, technical complexity) make it ideal for countries with high electricity demand and large grids, these qualities preclude it from countries with more modest electricity needs and smaller grids.⁴⁶ Furthermore, global construction statistics confirm a broad preference for the simpler, cheaper and proven 2nd generation reactors: of the 42 reactors under construction, only 13 are

3rd generation. The performance of the forthcoming Atmea and Karena reactors will thus be very important for “Equipe France,” particularly in emerging markets without nuclear experience.⁴⁷ More fundamentally, as François Roussely has noted independently of his commission’s formal report, France’s advantage lies more in EDF’s experience than in Areva’s technology:

Today, we are no longer the only ones who know how to make quality reactors and turbines. On the other hand, we are the only ones who are able to provide a newcomer (to civilian nuclear energy) with the field experience of an operator that has managed 58 nuclear reactors for thirty-five years with no major accidents.⁴⁸

It should be added that, despite the risk entailed in an integrated French nuclear export model, Areva and EDF remain well-positioned to answer calls for nuclear reactor contracts abroad, individually and as a unit. French corporations, particularly Areva, have cast a wide net over recent years as countries began to discuss investment in nuclear energy. Plans are in motion to construct EPRs in the United Kingdom, India and Italy.⁴⁹ The Kuwaiti Investment

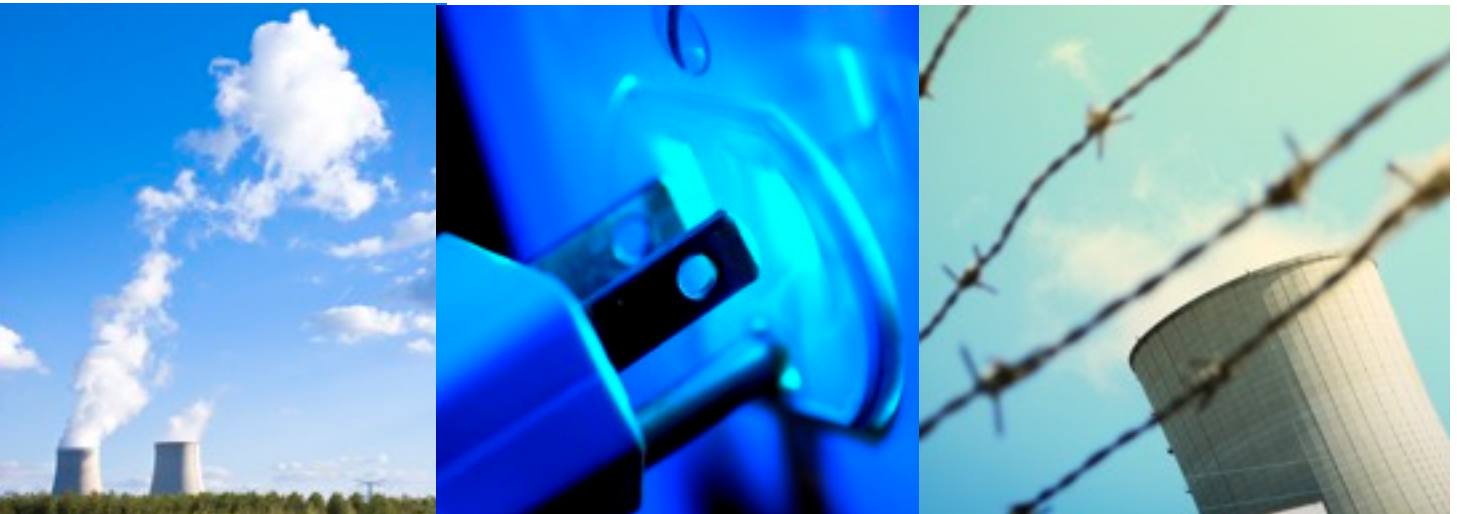
Authority’s recent €600 million investment in Areva bodes well for the export of French civilian nuclear technology to this Gulf state, and South Africa is considering French nuclear technology for its planned reactor fleet expansion. The reactor fleet within France is also aging and in need of replacement.

It is unclear, however, whether a unitary French nuclear export offer is the optimal arrangement for both EDF and Areva. By depriving both corporations of a free hand in countries in markets where the other indicates interest, the Roussely Report may preclude Areva or EDF from making the most competitive bid. Areva brings advantages of its own, namely its fuel cycle operations, to an integrated French export bid. However, until Lauvergeon’s corporation widens its portfolio of reactors and demonstrates that the EPR is deliverable, cost-effective and lives up to its billing in terms of safety and security, Areva is likely to be the weaker partner in joint reactor contract deals. Alternatively, the long-term nuclear fuel deal between Areva and EDF is designed to benefit EDF at Areva’s expense. In short, both corporations are asked to sacrifice for the “greater good.”

The Roussely Report is impressive for its candor and scope, addressing the host of issues ailing the French nuclear industry. However, on the fundamental question of how EDF and Areva will act when targeting the same market, it essentially “doubles-down” on the principle of unitary French action abroad. Instead of choosing an export structure that provides complete freedom of action to EDF and Areva, allowing each to pursue projects abroad irrespective of the nation-of-origin of its partner, the Roussely Report casts their lots together when both express interest in a given deal. And although much of EDF and Areva’s future activity abroad will be conducted independently, the value of reactor deals is so large (as seen in the Emirates) that sacrificing competitiveness in even a few markets could mean billions of dollars in lost revenue. This model increases the risk of failure by making the French bid more inflexible and less adaptable to the particular dynamics of different contract competitions. The Roussely Report’s proposed export arrangement will almost certainly be to the disadvantage of members of “Equipe France,” particularly EDF, in the short-term.⁵⁰

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ENDNOTES

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"Compte rendu du Conseil de Politique Nucléaire du 21 février 2011. » from the Elysée. February 21, 2011. <http://www.elysee.fr/president/les-actualites/communiqués-de-presse/2011/compte-rendu-du-conseil-de-politique-nucleaire-du-10715.html>
2. "Equipe France" or "Team France" in English is a term that appears in the Roussely Report. It refers to French industrial giants Electricité de France, Areva, Alstom, Bouygues and Vinci. EDF and Areva are the two most important "team" members and stand at the center of French nuclear export strategy.
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4. "Nuclear Power in France." World Nuclear Association. January 21, 2010. <http://www.world-nuclear.org/info/inf40.html>
5. Schnieder, Mycle. Nuclear Power in France: A Model? In *Nuclear Power's Global Expansion: Weighing Its Costs and Risks* by Henry Sokolski. December 2010. p. 238.
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12. Hauet, Jean-Pierre. « Le nucléaire français après Abu Dhabi. » *la Revue Passages*. « Passages50 : Lettre n. 6: le nucléaire dans tous ses états. » pp. 16-40. Here is the sentence in the original French: « Areva, pour lequel Abu Dhabi et les pays proches de la Méditerranée ne constituaient pas une priorité, s’est ainsi retrouvé au cœur d’un projet avec le sentiment qu’il était bien parti. » (p. 33)
13. « Emirats arabes unies » France diplomatie. July 20, 2010. http://www.diplomatie.gouv.fr/fr/pays-zones-geo_833/emirats-arabes-unis_428/index.html
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15. *Ibid.*
16. “Emirats arabes unies: Présentation. » France diplomatie. July 20, 2010. http://www.diplomatie.gouv.fr/fr/pays-zones-geo_833/emirats-arabes-unis_428/france-les-emirats-arabes-unis_1138/presentation_5026/index.html
17. Hauet, Jean-Pierre. p. 34.

Although GDF Suez operates and has constructed reactors in Belgium, it does not have as much experience as EDF (due to the scale of EDF’s reactor fleet). “GDF Suez: Activités: Le Renouveau de l’Energie Nucléaire. » GDF Suez. <http://www.gdfsuez.com/fr/activites/nos-energies/nucleaire/le-renouveau-de-l-energie-nucleaire/>
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22 The French Civilian Nuclear Industry (con'd)

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35. *Ibid.* p. 7
36. *Ibid.* p. 14. The Roussely Report places emphasis on EDF and Areva's strategic partnership, calling it a pressing necessity ("nécessité impérieuse").
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50. I owe a debt of gratitude to Dale Swartz, Cheryl Miller, and Wesley O'Dell for their help in editing this piece.



24 Questions About Nuclear Deterrence

By Ward Wilson, Director of the Rethinking Nuclear Weapons Project

People often talk about nuclear deterrence as if it were a known quantity, a thing that could be examined and tested using scientific principles. And that makes sense to us. After all, we've based our foreign policy on it for forty years or more -- we have a right to feel as if we have considerable experience with it. But despite these feelings, the fact is that nuclear deterrence rests far more on belief than evidence.

The evidence for nuclear deterrence is like a distant, shimmering mountain in the hot desert: it seems substantial, but the closer you get, the more it dissolves before your eyes. The four most disturbing problems with the evidence for nuclear deterrence are 1) a lack of evidence about nuclear weapons in general, 2) reevaluations of Hiroshima, 3) historical failure of city destruction, and 4) the logical weakness of the proof for nuclear deterrence.

The most troubling thing about the nuclear weapons field as a whole is that there is almost no real evidence to draw conclusions from. Nuclear weapons have only been used twice (at Hiroshima and Nagasaki) and our experience with other weapons shows

that it takes a fair amount of actual experience before people understand the properties and implications of a new weapon.

Machine guns, for example, were known to the European powers for at least thirty years before World War I, and were often used in colonial wars. Yet when World War I broke out, the general staffs of France, Germany and Great Britain still ordered men to charge machine guns in masses over open ground. It took at least two more years of repeated experience (with disastrous results) before they began to realize that such attacks were pointless.

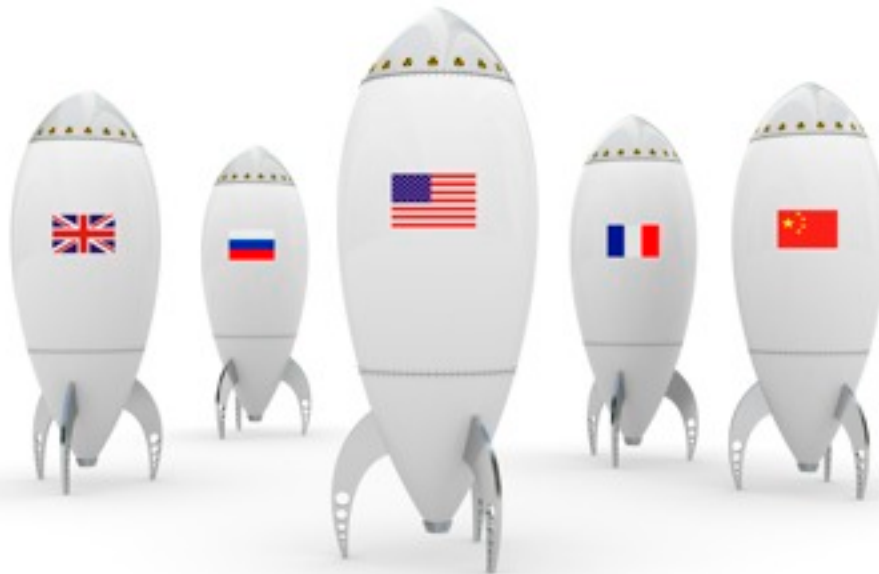
To understand the full implications of nuclear weapons and to understand their characteristics in detail will require - what all other weapons systems require - repeated field testing under battle conditions. We are not likely (it is to be hoped) to collect this information. This means that where nuclear weapons are concerned we are operating with a severely limited body of knowledge.

Of course, deterrence is a particular kind of threatening. There have been many threats with nuclear weapons and

some of these have seemed to work. So one could argue that threats have been field tested. The problem is that threats are psychological: it is extremely difficult to gather reliable facts from inside the heads of historical actors. So with little battle testing and given the inherent limits on plumbing the depths of human psychology, there is little hard evidence to go on.

The second problem with the evidence for nuclear deterrence has to do with recent developments in the historical interpretation of Hiroshima. It has long been assumed that Japan surrendered because of the nuclear attacks against Hiroshima and Nagasaki and that President Truman's threat of a "rain of ruin" effectively coerced Japan's leaders. Nuclear deterrence is founded, in part, on Henry Stimson's argument that nuclear weapons - as they demonstrated at Hiroshima - have a powerful ability to shock an enemy - a unique psychological ability to coerce and deter.

In the last twenty years, however, historians have opened up archives in Japan, Russia and the United States and quietly begun to doubt this interpretation.¹ It seems clear from the



evidence that Japanese leaders were concerned about the Soviet Union's declaration of war on August 8th, and that they weren't very much concerned at all with the nuclear bombings. It is certainly true that after the war they used the nuclear attacks as an excuse for having lost, thus saving face for the military and preserving the legitimacy of the Emperor, but contemporaneous records - diaries, meeting notes, etc. - show that they paid little attention to the city bombing that the United States was carrying out that summer - conventional or nuclear.

If Japan didn't surrender because of the threat of nuclear attack, it undermines much of what we know about nuclear deterrence. Where is the unique ability to shock and overawe if Japan's leaders clearly weren't either shocked or overawed? The one real battlefield test of nuclear weapons now seems to work against the effectiveness of nuclear deterrence, rather than for it.

The third problem is the quite large body of historical evidence that seems to contradict nuclear deterrence.

Nuclear deterrence is founded on the threat to destroy cities, and - in peacetime, at least - the threat to destroy cities seems impressive. The record from wartime, however, is almost exactly the opposite. No war has ever been won by city bombing. City bombing was certainly ineffective against Great Britain, Russia, China, Germany, and - if you accept the revised interpretation of Hiroshima - Japan. In other words, city bombing never worked to win a war. And this fits

with the larger historical pattern about city destruction. City destruction has never worked to coerce surrender. For example, when Magdeburg was destroyed by Imperial forces in 1631 during the Thirty Years War and 30,000 killed, not only did the Protestants not surrender, recruitment and support surged across Europe.

It may be that nuclear destruction would be greater than conventional attacks have been (although many of the conventional attacks on Japan caused more destruction than the attack on Nagasaki and some conventional attacks killed more people and were more destructive than Hiroshima). One could argue, therefore, that a nuclear attack might be more effective than a conventional one. But that is simply speculation. The evidence shows that no known level of civil damage causes surrender. Despite our intuition that nuclear deterrence would work - our very strong intuition - intuition is still not evidence.

Fourth and finally, there is the shakiness of the "proof" that deterrence works. The claim that nuclear deterrence works because there has been peace for more than 60 years is proof by absence, one of the weakest forms of proof. It requires that there be only one possible cause of peace. If nuclear deterrence is the only thing that can cause peace, then the proof succeeds. But if there is any other possible cause, the proof fails. And there are many reasons why there might have been peace for the last 65 years.

These reasons include close economic and trading ties between nations and the strength of alliances and international organizations like NATO, the UN or the European Union. Also, peace could have resulted from simple exhaustion. The Soviet Union lost about 27 million people in World War II and 30 to 40 percent of its industrial capacity. It is hardly a surprise that the Kremlin didn't want to fight a war during the next twenty or thirty years. And history provides evidence on this point: there are quite lengthy periods of peace after both the Thirty Years War and the Napoleonic Wars.

The recent absence of wars between major powers also could have been the result of closer ties as the result of jet travel, easier immigration, and television. It might have been the result of U.S. conventional strength in the 1980s and 1990s. It might be that it just isn't time for a major war yet. There is a theory that major wars only come every 100 years: the Thirty Years War in the 16th century, the Seven Years War in the 17th, the Napoleonic Wars in the 18th, and World Wars I and II in the twentieth. Finally, sometimes in history there are just periods of peace. Ancient Egypt knew peace for 200 years. But that didn't have anything to do with nuclear weapons.

Nuclear deterrence feels like a steady certainty, but there is a troubling lack of evidence that it actually works or even exists. If we are going to risk our lives and the survival of our nation by relying on nuclear deterrence, doesn't simple prudence dictate that we find real evidence that it works? **FAS**

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Ward Wilson is a nuclear weapons policy analyst who is increasingly the source of fundamental reevaluations of nuclear weapons and challenges to Cold War notions. Wilson is a Senior Fellow at the James Martin Center for Nonproliferation Studies at the Monterey Institute of International Studies. He also directs the Rethinking Nuclear Weapons project.

By Monica Amarelo of the Federation of American Scientists

On October 6, 2010, FAS honored Dr. John Holdren, the Director of the White House Office of Science and Technology Policy and Science Adviser to the President of the United States, and Ms. Barbara Pyle, an Executive Producer, Director, and Environmentalist at a dinner event at the Carnegie Institution for Science in Washington, DC.

The 2010 FAS Awards Ceremony was an evening of celebration in support of the award recipients and FAS's 65th Anniversary.

Dr. Holdren received the prestigious 2010 Hans Bethe Award for his enduring work on complex global issues that hinge on science and technology, such as the causes of climate change, analysis of energy technologies and policies, and ways to reduce the dangers from nuclear weapons. An excerpt from his remarks is available on page 28.

FAS honored Ms. Pyle with the FAS 2010 Public Service Award for her groundbreaking work in environmental television programming. She is a champion for energy efficiency and recycling, and created the beloved animated action adventure series Captain Planet and the Planeteers (see page 27).

The evening's Master of Ceremonies was Bianca Jagger, founder and chair of the Bianca Jagger Human Rights Foundation which calls attention to the need for greater access to low carbon energy sources for human development and protection of the environment.

The attendance of U.S. Department of Energy Secretary Dr. Steven Chu at the reception was a great distinction for FAS and the awardees.

Since 1971, FAS has recognized an outstanding public interest advocate who has made a distinctive



Photos by Monica Amarelo.

From left to right: 2010 Public Service Award recipient Barbara Pyle, FAS President Charles D. Ferguson, master of ceremonies Bianca Jagger, and 2010 Hans Bethe Award recipient John Holdren.

contribution to public policy at the intersection of science and security. Past recipients include Senator Edward M. Kennedy, Richard Garwin, Carl Sagan, and Phillip Morrison.

The Hans Bethe Award is named for one of the FAS founders and the Nobel Prize-winning nuclear physicist who helped develop the atomic and hydrogen bombs and later became an advocate of non-proliferation.

The evening's festivities would not have been possible without the generous support of our Sponsors, which included Gold Sponsors – General Atomics, HBO,

Roger and Vicki Sant; Silver Sponsors – Residue Regency Pad Corporation, USA Science and Engineering Festival; Bronze Sponsors – Bellona USA, Lashof Family Charitable Gift Fund, Rodney W. Nichols, Arthur H. Rosenfeld, Sigma Space Corporation, Turner Foundation Inc.; and Green Sponsors – The Federation of Electric Power Companies of Japan and Laura Turner Seydel. (list on page 30)

For more information on the 2010 FAS Awards Ceremony, to view photographs and video, please visit: <http://www.fas.org/about/2010awards.html>.

FAS

For more than 30 years, Barbara Pyle has pioneered the use of film and broadcast programming to highlight environmental issues and global concerns. This year, FAS recognized this environmental champion with the 2010 Public Service Award for her critically acclaimed news coverage, her support of energy efficiency and recycling, and for creating the animated action adventure series “Captain Planet and the Planeteers.”

"Our planet will not be saved by any one big decision," said Pyle, "but by many individual choices - choices by people like you and me. Television has an important role in providing the information necessary to enable us to make these choices."

In 1980, Barbara Pyle met Ted Turner and joined the Turner Broadcasting System (TBS) to create the Turner Environment Division and make critical global issues understandable and accessible to a wide audience. For 20 years, Pyle served as corporate vice president of environmental policy at TBS, setting the company's environmental broadcast agenda and branding TBS as the environmental network.

She also served as the Cable News Network's (CNN's) environment editor and created *Earth Matters*, CNN's weekly environmental news program. Her programs put a human face on the global issues of the environment and sustainable development.

Twenty years ago, Ted Turner and Pyle co-created “Captain Planet and the Planeteers.” The program originally aired on TBS SuperStation, syndicated in 223 markets and broadcast worldwide in the 1990s.

“We do not have time to train this generation of teachers, to train the next generation of students about environmental issues, because we do not have generations, we have years,” Pyle quoting her friend Lester Brown, founder and president of the Earth Policy Institute.

The groundbreaking environmental series quickly rose to number one in Nielsen ratings for children's programming and was honored for best animation at the Environmental Media Awards for the six years it was on the air.

Broadcast in more than 100 countries, Captain Planet inspired millions of children to protect the environment, to become more energy efficient, and to respect cultural diversity.

Captain Planet's legacy lives on through the Captain Planet Foundation, a non-profit organization which engages and educates children through hands-on environmental activities.

For information on Barbara Pyle, please see the Barbara Pyle Foundation website: <http://www.barbarapyle.com/foundation/>

To learn more about Captain Planet and the Global Planeteer Movement, please visit: www.captainplanet.me.

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Director of the White House Office of Science and Technology Policy John Holdren accepts the FAS 2010 Hans Bethe Award.

It's absolutely wonderful company to be in, and I couldn't be more honored to be here. I was the Chairman of the Federation of American Scientists in 1984 and 1985 - an earlier era - but that was a great honor and privilege as well. And I'm delighted to have had that long association with FAS.

I want to say just a word, and I'll be brief because of the late hour, about science and technology in the Obama administration.

President Obama promised in his campaign, and then in his inauguration speech, that he would put science in its rightful place in his administration. And what he meant by that was not that science and technology would necessarily dominate decision making, not that the opinions of scientists and technologists would necessarily determine outcomes in the great policy decisions that the government faces.

Rather he meant that science and technology would always be at the table. That the facts as understood from science and technology would always be taken into account, would always be germane. Again that didn't mean that political considerations, economic factors and a

variety of others would not be taken into account as they must be in the political process, but that science and technology would always be heard.

As I often said to my students over the years in teaching courses about science and technology policy, "The facts from science and engineering are rarely everything but they're almost always something."

And it is unwise to form science and technology policy in ignorance of or deliberately ignoring what we know from science and technology that bears on those decisions.

And one can see the ways in which President Obama fulfilled that promise in a number of different dimensions.

First of all, who he appointed. There are five Nobel laureates in science serving as presidential appointees in this administration. Five. Secretary Chu in the Department of Energy. Dr. Carl Weiman, recently confirmed as the Associate Director for science in my office, the Office of Science and Technology Policy - another Nobel laureate in physics, like Professor Chu. Dr. Harold Varmus, the head of the National Cancer Institute, a Nobel laureate in physiology or medicine. And two members of the President's Council of Advisors on Science and Technology -- Mario Molina and Ahmed Zewail - both Nobel laureates in chemistry.

That's extraordinary. I'm sure that there's never been an administration in U.S. history that has had five Nobel laureates serving in presidential appointments.

There are 25 other members of the National Academy of Sciences, National Academy of Engineering, and National Institute of Medicine serving in presidential appointments in this administration.

One sees it as well in the way and the amount in which the president talks about science and technology. No president has ever talked as much

about how and why science and technology matter for the great challenges that our country and the world face. How science and technology matter for the economy through the innovation that will create new products, new jobs, new opportunities. How they matter for healthcare. The ways in which science and technology can enable us to get better outcomes for more people at lower cost. How they matter for energy and environment. How science and technology are going to be the keys to enabling us to provide the energy needed to create and sustain prosperity everywhere without wrecking the environmental conditions and processes on which our well-being also depends. On science and technology we need for national defense and for homeland security.

This president really does get it.

I was actually astonished to discover in my early meetings with this president that my job was not mainly tutorial. I thought initially as the President's Science and Technology Advisor that my job would be to explain to a president without significant discernible background in this domain how science and technology work, what they have to contribute. Turns out that the president knows that already. Knew it already.

When I go in to meet with him I almost never have to explain to him how the relevant science and technology work. He already knows it. We go immediately to the question of what should we do, how do we get this done, how can we move forward in the applications of science and technology to these great challenges.

One sees his commitment in this domain in the budget initiatives, not withstanding the budget challenges that we face. In the 2011 budget, the president's proposals lifted the amount of support for basic and applied research together. Kept the National Science Foundation, the DOE Office of Science, the

National Institute of Standards and Technology labs – on a trajectory to double in ten years. Added a billion dollars to NIH.

This is a president who understands why it's important to continue to invest in science and technology. It's an investment in our future, even as financial challenges make it harder and harder to do that.

You see it in his initiatives.

The new American Strategy for Innovation. The "Innovation Initiative" which has generated half a billion dollars in private and philanthropic contributions to lift the level of K – 12 science and math education in this country. The "Change the Equation" initiative that has 100 CEOs committed to help us to create 100,000 new science and math teachers for high school.

You see it in the vision the president has articulated about a declining role of nuclear weapons in the world, leading ultimately to a world in which we have figured out how to prohibit nuclear weapons all together.

You see it in the vision for a comprehensive approach to energy and climate change. It solves these problems together.



Dr. Richard Garwin with United States Secretary of Energy Steven Chu.

We have a lot that we have gotten done in this administration in the domain of science and technology, and its relevance to the great challenges we face.

We have a lot that we haven't gotten done. And there have been perhaps too many disappointments. It's a difficult environment. We have a lot more to do.

What I can assure you is that this president and his team in the science and technology domain are absolutely determined to forge ahead, to meet these challenges that we face. With respect to comprehensive energy and climate legislation, the message is we didn't win this time around in Congress, but we'll be back.

And I'm pleased and honored that Deputy Secretary of Energy Dan Poneman is sitting there at the front table, and Dan and Secretary Chu, who was here earlier for the reception, are crucial partners in this effort. There is absolutely no wavering of determination to get this done. There is no wavering of determination to use

science and technology to meet the healthcare challenge. No wavering of determination to move forward with the global development strategy with science and technology at its center.

The administrator of USAID Rajiv Shah - a brilliant young guy - is absolutely committed to having science and technology at the center for strategy for sustainable development.

We are going to get it done.

And I want to say that the support of the wider science and technology community, the wider intellectual community represented here, the NGOs – of which FAS is such a shining example – and the brilliant interveners and activists are key to getting this done.

So I thank you all for all that you've done and all that you will do as we face and meet these challenges together going forward.

Thank you very much. **FAS**



Secretary Chu with John Holdren.

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The Students for International Security (SIS) is a student outreach effort to provide the next generation of scientists and engineers a vehicle to further the conversation on security and science topics, and to impact policy decisions made in Washington and abroad in a nonpartisan way.

SIS groups provide a venue for undergraduate and graduate students, university faculty, and experts to come together to discuss important issues.

Many FAS members are academics or technical experts in a wide variety of disciplines, teaching at major universities across the country, and holding high level positions in the non-profit, for-profit, and governmental worlds. To get involved please contact James Wright at jwright@fas.org.

To learn more about SIS, visit:
<http://www.fas.org/member/sis.html>.

Call for Articles

In an effort to provide timely articles about security policy, nonproliferation, earth systems, educational technologies and other areas of science and technology policy, FAS members are invited to submit proposals for articles (maximum of 1,500 words).

Selection of articles is at the discretion of the editor and completed articles will be peer-reviewed.

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