Thomas Sanders: A right-sized future

The 55th president of the American Nuclear Society is promoting small reactors as a way for the United States to get back into the nuclear manufacturing business and compete in the global marketplace.

BY RICK MICHAL

THOMAS SANDERS WANTS the United States to get back to manufacturing nuclear systems—specifically the components for what he calls "right-sized reactors"—for a global market.

Sanders, the 55th president of the American Nuclear Society, is manager of the Global Nuclear Futures Initiative at the Department of Energy's Sandia National Laboratories in New Mexico. The program's objective is to ensure that the global expansion of nuclear power does not result in a corresponding increase in nuclear proliferation.

Sanders is a true believer in landscaping the United States—and the world—with right-sized reactors, which would be rated at 100 to 300 MWe and could be brought on line about two years after the start of construction. The cost of one reactor would be relatively low—$200 million to $300 million—compared with the billions of dollars needed to build large next-generation nuclear plants.

Sanders points out that the United States was once an international leader in providing nuclear goods and services, but not anymore. "The bottom line is that most of our supply industry for manufacturing large nuclear systems is gone," he said. "It's moved offshore so that we are now a net consumer, not an exporter, of nuclear goods and services."

He applauds some foreign nations—France, Japan, Russia, China, and South Korea—for taking action in their own national interest to ensure that critical infrastructures—the nuclear industry, nuclear education, and national laboratories—are healthy, but he worries about these same infrastructures in the United States. "While other nations are investing in and promoting their nuclear enterprise throughout the world, we can't even come to grips with loan guarantees for nuclear projects here at home," he said.

Without loan guarantees, he wonders which utility or conglomerate can take on the first-of-a-kind costs and risks of building a large new reactor. Sanders thinks it will be a foreign government, through a government-owned business entity, that will be the driving force behind the first new build in the United States. A foreign entity—such as Areva, which is owned by the French government—could take an equity position in the project and hold a stake in the American electricity market while sending profits overseas.

To get the United States back in the ballgame, Sanders wants the developing nuclear renaissance to include the United States' having a vested interest in the manufacture of right-sized reactors, which would be much less of a financial risk for buyers than large plants and could be added incrementally, much like gas-powered electricity generating plants are added today. These small reactors could be used for electric power generation and for other purposes, such as processing heat for other industries or for producing hydrogen and potable water.

If the United States were to start manufacturing these systems for export, in addition to offering other nations fuel services such as spent fuel "take-back" for recycling and disposal, a two-pronged positive effect would result, he said: The United States would benefit from the revenues that would be generated, and it would also have influence over how other countries deal with nuclear proliferation issues. "If we don't manufacture anything for export, or offer fuel return services such as reprocessing or spent fuel storage, how exactly can we get a country like Iran to stop its uranium enrichment program?" he asked.

How Sanders arrived at these strong positions is due to unplanned circumstances. It is likely, however, that good genes and the United States' involvement in Vietnam during the 1960s steered him along the way.

Early on

Sanders was born in 1946 in the small Texas town of Sinton, population 5000, not far from the Gulf of Mexico. His father, a World War II veteran, split his time between working at an oil refinery and as a crop duster. His mother stayed at home raising Sanders and his siblings. Sanders was a good student, although he showed no particular interest in math and science, and he was active in Cub Scouts and Boy Scouts.

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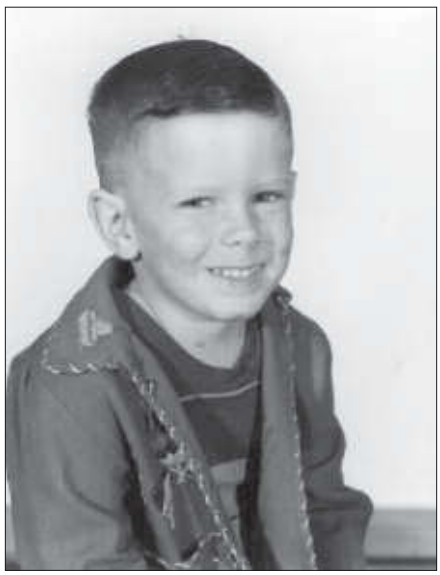

Sanders the boy, circa 1954

No. 35, Tom Sanders, as a member of the high school football team in 1963

In the 1950s, the American Dream meant owning a home, and about the time Sanders started high school, the Sanders family moved in to a house of their own in Sinton. "My parents are a great example of the post-war movement of young families rising to the middle class," he said.

The new house cost $4000 and had only one bedroom, but it was soon expanded. "In those days, the extended family would get together with saws and hammers and add on rooms," he recalled. "I believe I could still build a house from scratch right now."

The family later moved to an $18 000 brick house in Portland, Texas, on the coast of the Gulf of Mexico.

In high school, Sanders did well in his classes and in sports, but he gave little thought to the future. His father came from a line of farmers, and his mother was from the Texas hill country, where people cut down trees for a living. "We had no intrinsic aspirations for college," Sanders said. "In fact, out of my entire extended family, only a cousin and I went on to get college educations."

After graduating from high school at 17, Sanders took time out for a big adventure. It was 1964 and the Beach Boys were on the music charts, and Sanders had a cousin who lived near the ocean in Ventura, Calif. With $100 and a bus ticket given to him by his father, Sanders went west to catch a few waves. While in Ventura, Sanders took classes at a junior college and realized that he was suited for a career in technology. For the time being, however, life was living near the beach and having fun.

At 18, Sanders bought a car and decided to go back home to Texas, where he divided his time between attending a junior college and working. "Living close to the water during the summer of 1965, I worked on chartered fishing boats, baited hooks, opened beer cans for fishermen, and did some deep-sea fishing on my own," he recalled fondly.

He moved on to labor on the tugboats that supplied offshore oil rigs. "Great paying jobs," he said. "I was paid for 24 hours a day while I was out there, and then I could take off for a week and do whatever, spend my money, have a good time."

That all changed in August 1966, when he was two months shy of his 20th birthday. "This is a story I love to tell to young ANS members and students," he said, "because you never know what's going to happen in your life."

Sanders had saved up to buy a brand new Harley-Davidson motorcycle. After checking out the bike at the dealer, he handed his father some finance papers to cosign. In return, his father handed him an official-looking envelope. "It was from President Lyndon Baines Johnson and it said 'Greetings, Tom Sanders. You are to report for duty one month from today for induction into the armed services of the United States,'" he said.

The Vietnam conflict was under way, and Sanders had already given thought to Uncle Sam's coming for him because many of his friends had enlisted during 1964 and 1965. He knew that the only alternative to military service was to attend college full time, which he wasn't ready for. Instead, he spoke with Navy recruiters. "They looked at my high school record, gave me some tests, and I aced them. I got 137 out of 140 in an aptitude test," he said.

Best man in a wedding in 1967

Sanders's test scores qualified him for the nuclear Navy. "The recruiter said that it was brand new, they were building submarines, and it was a six-year program," Sanders said. "He said that if I didn't know what I wanted to do yet, I should try it out. So I did."

During his six years in the Navy, Sanders learned all there was to know about operating a nuclear reactor. After boot camp, he became an electrician's mate, and from there he went to the Navy's nuclear power school—seven months of 12-hour days. Then it was on to classroom training and hands-on experience on a prototype nuclear power plant. Next came submarine school, and, finally, after more than two years of training, assignment to a nuclear submarine.

"My first submarine, the USS *Kamehameha,* was one of the brand-new Polaris submarines. We did duty out of Hawaii, and the sub sailed out of Guam. I went out to sea for 90 days and then lived on the beach in Hawaii for 90 days. For a 21-year-old, it wasn't bad," he recalled with a grin.

Eventually he transferred to a fast-attack sub named the USS *Shark,* one of the first nuclear-powered vessels.

Although bitten by the nuclear bug, Sanders wanted to try something different after six years in the Navy. He has never regretted his time in the service. He had risen to become qualified to supervise all operations of a Navy reactor. "Submarines are different from commercial power plants," he said. "We would have drills, including reactor scrams with full-scram recovery, every week for training. We did all kinds of drills because we were in a war-ready platform and knew that we would have to be able to continue our mission under any circumstance."

He called the smaller reactors on the subs "phenomenal" because they could go from full stop, to back full, to all-ahead forward as quickly as a young submariner like Sanders could open the throttle. "You're going directly from 10 to 12 percent power to 50 percent, or even 100 percent power, in a matter of seconds," he said. "That's a lot different from what a commercial reactor could do. It's a load-following capability that is rare, and it was exciting to watch how the plant responded."

He marvels at the training he received at the Navy's Nuclear Power School and the prototype plant, and remembers that while sitting at the control area he could see everything that was going on with the nuclear system, whether it was steam moving out of the steam generators, heat added to

Sanders the submariner was awarded the Navy's Good Conduct and Meritorious Unit Medals in 1971.

the reactor, or the mechanisms that give feedback on the reactor's operation. "It was an amazing opportunity," he said. "I would encourage any engineer who is looking for a career start to consider the Navy because it provides a base that can't be duplicated anywhere."

His youngest son, in fact, is a reactor operator on the USS *Hawaii* submarine. (Of his other five children—all sons—two are Rangers in the U.S. Army, one is a lawyer, another is a businessman, and one is a music technician.)

Sanders left the Navy in 1972 as a 25-year-old with a special set of skills. He officially off-boarded from the service on the East Coast of the United States, and as a nuclear-qualified journeyman electrician, he went to work in a shipyard in Virginia. After a year, he headed back to Texas for three reasons: He missed being home, he could become a full-time university student using the GI bill, and he had an urge to see how far he could go in developing a real capability in nuclear engineering.

A nuclear engineer

Sanders enrolled at the University of Texas (UT), where from 1974 to 1985 he earned his bachelor's and master's degrees and a Ph.D. in mechanical engineering with an emphasis on nuclear engineering. He started graduate school in 1977 under Linn Draper, who later became an ANS president (1985–1986) and chief executive officer and president of the American Electric Power Company. During the late 1970s, Draper regularly engaged political activist Ralph Nader by debating him around the country on the virtues of nuclear power, according to Sanders. Wherever Nader was invited to provide his antinuclear rhetoric, Draper was often there to counter him.

A new nuclear engineering professor at UT in 1977 was Dale Klein, who is currently a member (and former chairman) of the Nuclear Regulatory Commission. Sanders recalls that Klein took him and some classmates to a viewing of the movie *The China Syndrome*—a fictional tale about safety cover-ups at a nuclear power plant—about a week before the real-life accident at the Three Mile Island-2 nuclear plant.

While at UT, Sanders also received a senior reactor operator license on the university's TRIGA reactor and did research into gas-cooled fast breeder reactors and fission-fusion hybrid systems. In earning his Ph.D., he performed experiments that had never been done before, such as experimentally validating a theory he had developed for the magnetohydrodynamic flow of a liquid metal in a bed of conducting spheres. Sanders proudly notes that another researcher later named the constant in the empirical relationship after him.

UT is located in the city of Austin, which Sanders describes as politically liberal and which wanted no part of nuclear power after the TMI-2 event. At the time, the municipal utility owned part of the South Texas Project (STP) nuclear power plant, which was under construction. The city offered a referendum with every election to try to abandon the project, but each one failed for financial reasons—electricity from STP would be cheaper than from other sources. Sanders said that during this time, he and his fellow students got involved in debating the antinukes in and around Austin and debunking what he called their pseudo-science scare tactics.

It was during the mid-1970s that Sanders joined UT's ANS student branch and became its president. "We'd go to shopping malls with this big analog display where we'd illustrate the projected growth in the world's population and the growth of energy sources needed," he said. "We were well received by people on the street, generally."

After receiving his Ph.D. in 1985, Sanders interviewed with several national laboratories. He chose Sandia because he was immediately offered a job in program management integrating several technical issues, such as burn-up credit and robotics, on the nuclear waste side of the fuel cycle. He has been with Sandia ever since.

Following his first job at Sandia, he got involved in working on what he calls the five D's—deactivation, decommissioning, decontamination, disposition, and dismantlement—and with developing advanced technologies to perform all of these operations at low cost. "We had technology initiatives

Sanders graduated in May 1985 with a doctorate in mechanical engineering (with a focus on nuclear science and engineering) from the University of Texas.

that ranged from electroslag refining of contaminated stainless steel to the development of very advanced robotic and automated systems that made the D&D processes much safer and more efficient," he said.

Sanders's projects involved the technical challenges associated with the five D's at the DOE's Rocky Flats, Hanford, and Savannah River sites, and the Los Alamos National Laboratory, all of which were part of the government's weapons complex and had facilities and areas contaminated with many types of by-products—from plutonium to fission products.

When Ukraine's Chernobyl accident occurred in 1986, Sanders was among the investigators who invited the Ukrainians to Sandia to find out how the United States could help with the cleanup.

Since the mid-1990s, Sanders has also been instrumental at Sandia in preparing assorted reports on nuclear nonproliferation, including a joint U.S.-Russian analysis in 2002 titled *The Global Nuclear Future: From Atoms for Peace to Atoms for Peace and Prosperity*; the joint action plan from 2003 titled *Nuclear Energy: Power for the 21st Century,* which was signed by the directors of six U.S. national labs; and a concept paper from 2005 titled *Atoms for Peace and Prosperity in the 21st Century.* In addition, in 2004 he developed a partnership initiative of the directors from seven U.S. national labs and nine Russian national labs titled "Toward a Global Nuclear Future: Concerning Sustainable Nuclear Energy for the 21st Century."

He has also authored more than 100 papers and articles for journals, conferences, and magazines that covered many aspects of the nuclear fuel cycle. For ANS, he has served as vice chair and chair of the Special Committee on Nuclear Nonproliferation, and since 2000 he has led congressional seminars on nuclear issues. Sanders was also the assistant general chair of the 2006 ANS Winter Meeting.

Security matters

When the Soviet Union collapsed in 1991, Sandia took on a mission to help Russia, Kazakhstan, Ukraine, and Belarus handle their excess nuclear assets and scientists. The situation, in Sanders's opinion, was a classic national security issue regarding nuclear proliferation, because the United States was getting out of the nuclear power business at the same time that the Soviet weapons complex was still burgeoning and in need of control and cleanup. Few seemed to realize that nuclear power was needed for arms reduction purposes as a bargaining tool and to burn excess high-enriched uranium (HEU) from the former Soviet states.

The Soviet Union's demise also meant that its nuclear supply deal with former Soviet bloc countries had collapsed. Under the deal, the countries received Soviet nuclear goods and services based on the supply-and-return concept—i.e., "you buy our reactor and fuel, we take our fuel back at the end of the in-core fuel cycle." The deal had been a very positive one for proliferation resistance, but now the world was suddenly stuck with unintended consequences. For example, one former Soviet state decided to start immediate research into spent fuel reprocessing to avoid being stranded with nuclear materials and having no place to dispose of them. Reprocessing, of course, can result in the separation of nuclear materials, some of which could be used to make bombs.

Sanders (second from right) and some nuclear specialists on a cold day in Kazakhstan in the early 1990s. The specialists were there to assist with the country's excess material issues.

Sanders was asked to be part of a group of specialists to go to Kazakhstan as part of an initiative to corral excess HEU. It was an emotional time, he admits, because he had been a Cold War warrior—from his Navy days and from his DOE work on security issues—and now there he was, dealing with former adversaries who were suddenly free to interact with the United States. "It wasn't that they had surrendered, it was just that the Iron Curtain had come down," he said.

The early 1990s were not kind to the nuclear industry in the United States, Sanders remembers. Deregulation came to the electricity market, the government's gaseous diffusion plants were privatized, the DOE was split into components, the U.S. nuclear weapons complex was shrinking, and the industry's leading technology research efforts by the government and private industry were solely focused on D&D. "On the one hand, we wanted to promote the transition of excess nuclear materials, people, and technology in the former Soviet Union to peaceful uses. On the other hand, we were at a time in the United States when nuclear technology was not in favor," he said.

By 1997, Sandia management had given Sanders the freedom and the budget to start articulating that nuclear energy was important to national health and security. Driving the message was the reality that the DOE's budget for nuclear energy R&D was near zero and the nation's educational and research infrastructures were rapidly disappearing. Highlighting those facts was then Sen. Pete Domenici, of New Mexico, who in 1997 gave his famous speech at Harvard University in which he said that the abandonment of nuclear technology was unacceptable. Sanders agreed. "We at Sandia, as a national security lab, were aghast," he said. "How were we going to influence the safety, security, and nonproliferation culture around the world if we were 'out of business'?"

That same year, Sandia started the Global Nuclear Futures Initiative program, with Sanders in charge. The program first focused on the management aspects of loose nuclear materials and how to get them under control. It then moved on to help build a bipartisan consensus—consisting of universities, the national research labs, and lawmakers—which was needed to promote reinvestment in nuclear energy research in the United States.

Under Sanders, Sandia teamed with former Sen. Sam Nunn and the Center for Strategic and International Studies (CSIS) on work that ultimately led in 2001 to billionaire Ted Turner's funding of the Nuclear Threat Initiative (NTI). (CSIS is a Washington, D.C.-based foreign policy think tank, and NTI is a non-profit organization whose mission is to strengthen global security by reducing the risk of use and preventing the spread of nuclear, biological,

and chemical weapons.) Today, NTI embraces the supply-and-return concept, and Turner has pledged to invest in the International Atomic Energy Agency's proposed nuclear fuel bank to ensure that countries that forgo enrichment have an alternative source of fuel if needed.

Nuclear infrastructure

People are caught off guard, Sanders said, when they hear him say that within 15 years, Westinghouse reactors, which were once made in the United States, will be coming out of China. Westinghouse is now largely owned by Toshiba, of Japan, and most of their reactor components are made in Japan. But a deal has been struck so that soon the manufacturing jobs will pass from Japan to China.

"When I talk with staffers on Capitol Hill, they're all shocked," Sanders said. "They ask how in the world could we sell Westinghouse to the Japanese? The answer is we didn't. Westinghouse was first sold to the U.K.'s BNFL. Then the British turned around and sold it to Toshiba for a substantial profit."

The same thing has happened with U.S. reactor vendor Combustion Engineering, which was sold to ABB Atom, which was co-owned by the Swiss and Swedish governments. Sanders also notes that General Electric is about 60 percent owned by Hitachi, of Japan, and that Babcock & Wilcox was bought by France's Framatome, which became part of Areva. The bottom line is that these reactor vendors that were once owned by U.S. companies are now largely controlled by foreign governments.

Sanders heartily supports the global expansion of nuclear energy, but he thinks that the United States should be a major part of it. He is convinced that the United States should offer nuclear services using the supply-and-return concept, which the Bush administration was attempting to do through its Global Nuclear Energy Partnership program. GNEP, however, received no funding in the DOE's proposed fiscal year 2010 budget, primarily because the national security benefits of the GNEP vision were lost in the scramble to capitalize on it, according to Sanders.

Sanders notes that President Dwight Eisenhower's Atoms for Peace program in the 1950s was all about managing the spread of nuclear technology around the world through a dominant U.S. industrial enterprise. In 1953, the United States tested the hydrogen bomb and the Soviets were close to doing the same thing. To avert an arms race, Eisenhower recognized that a peaceful U.S. nuclear program in the free world would give the Soviets an incentive to divert their materials, people, and intellect to a similar program behind the Iron Curtain.

Eisenhower also saw an opportunity for expanding the nation's newest strategic infrastructure—nuclear power—which was critical to enabling the growth of the program. The nuclear-powered submarine USS *Nautilus* was launched in 1954, and the government started subsidizing partnerships with American companies Westinghouse and General Electric to become the primary purveyors of technology for the Navy's defense applications. Sanders said that it makes sense now for the United States to follow that same line of thinking—to invest in American companies to become partners for defense and national security purposes—just as France's Areva is partnering with Northrop Grumman Shipbuilding to construct a $363-million facility in Newport News, Va., for manufacturing Areva's nuclear reactor components.

According to Sanders, Eisenhower recognized that if the United States had a robust industrial infrastructure in place, the likely spread of nuclear know-how and technology could be managed through the preeminence of a U.S. nuclear supply industry. Under Eisenhower's plan, the United States dominated the nuclear energy supply base until President Richard Nixon started the process of privatizing it in the early 1970s. Sanders said that Nixon didn't realize that by not expanding U.S. enrichment capability to service growing global needs, he was encouraging other countries to get into the enrichment business. In essence, startup businesses in the United States would be forced to compete with nation states in the export of nuclear goods and services. "It went on from there to what will ultimately result in Westinghouse reactors coming from China's state-owned enterprises within 15 years," he said.

The United States needs to return to Eisenhower's way of thinking, Sanders said. During his term as ANS president, Sanders will push for the United States to get back to manufacturing and supply as a tool for promoting nuclear nonproliferation. "We need to get to a point where people recognize that nuclear energy is good for environmental and energy security, and that having a healthy nuclear supply infrastructure here at home is good for our national security interests and our economic competitiveness," he said.

Sanders also will be looking to assist developing countries in meeting their growing energy needs by providing them with right-sized reactors. In exchange, these countries would agree to forgo uranium enrichment and reprocessing activities. Under the supply-and-return arrangement, these countries would be free from having to dispose of spent fuel in their own repositories. "Given the difficulties associated with developing a repository, I can't think of any nuclear country that would turn down the ability to send all their irradiated material back to their nuclear services supplier," he said.

Sanders feels that the Obama administration, while not embracing GNEP, clearly has an interest in nonproliferation issues, and so the supply-and-return scenario could be an option for consideration. The bottom line, Sanders said, is that there is an opportunity for ANS and its members to inform policymakers of the reality that the United States is falling behind the curve on nuclear issues.

The right size

Sanders said that manufacturing right-sized reactors would allow the United States to penetrate a market that is of limited

Sanders today with his wife, Barbara, and sons (from left) James, John, Andy, Phil, Ryan, and Pat

interest to the big players in the field. Sanders has no particular system in mind for a small reactor because there are about 50 small- to medium-sized designs and concepts in existence today. The large-scale development of these reactors would allow the United States to regain supply capability, he said, and such capability would trickle down to energy security, laboratory innovation, and university enrollments.

Looking at the potential market, the United States has added about 400 000 MW of gas-generated electric power since 1995, most of it coming from 100- to 200-MW systems, or the equivalent of one right-sized reactor. For the offshore market, while about 19 percent of the world's nations could absorb a 1000-MW reactor, the rest of the countries would be better suited—because of electricity grid restraints—for right-sized reactors, Sanders said.

As far as the land space needed, a 100-MW reactor would be as small as 3 meters in diameter and could be placed underground for security reasons, in an area perhaps 10 meters by 10 meters. Small, fast, and thermal reactors have already been demonstrated, he said, and future reactors could be fast, metal-cooled, and low pressure on the primary side so that complex pressure vessels would not be needed. The reactor could also load follow, which larger units don't do because their high capital costs require that they be kept at peak loads at all times. Sanders said that a first landing spot for the right-sized reactors could be the Department of Defense, which could use them for the energy independence of military bases.

The year ahead

Sanders and his wife, Barbara, reside in a home on 40 acres in the Sandia mountains just east of Albuquerque, N.M. He relaxes by working the land, he said. The family moved there in 1992 when Sanders's oldest son was 12 and the youngest was about 4. "We started them at sports activities at 4, and we put them all to work around 8 years old," Sanders said. "I believe that when you raise kids, you keep them so busy that they can't get into trouble. We started building a railroad-tie wall around the back of the house when we first moved there, and we finished it when the last son graduated from high school."

So far so good for the Sanders sons, who are all accomplished and who make their parents proud, he said. Sanders and his wife became first-time grandparents this year when son Ryan and his wife, Samantha, had their first child, Rylee Jane.

Sanders said that the message he will deliver during his term as ANS president fits in with what he is doing for Sandia: promoting national security, particularly the intersection of proliferation prevention and the global growth of nuclear energy. He also plans to work to expand membership globally because foreign nations are eager to obtain nuclear goods, services, and advice.

"I see an opportunity for ANS to do what it did in the earlier days with France, Japan, China, and other countries to develop relationships that promote our values with respect to safety, security, and nonproliferation on a society-to-society basis," he said. He mentioned, for example, that countries such as Malaysia and the United Arab Emirates are developing the basis for an emerging nuclear regulatory environment and are inventing their nuclear infrastructures from scratch.

The prospect of global associations brings Sanders back to the issue of American competitiveness. "A reason we're in the financial doldrums today is that we're so dependent on imports in almost everything that we've lost control of our own ability to influence others through the marketplace," he said.

The bottom line, he said, is that the United States can influence what goes on in the nuclear world only by being a major provider of nuclear goods and services through public and private partnerships, and by making smart choices on the types of nuclear systems that will be built here and offered internationally for export.

"The time is right," he said, "for a new right-sized reactor enterprise." NN