

ANS ANNUAL MEETING

Nuclear power: Clean energy leader

Session coverage:

- *Power reactors operating under “market flaws”*
- *Prospects for deployment of non-light-water reactors*
- *How states might address the Clean Power Plan*
- *Challenges in the management of used fuel and radwaste*
- *New reactor construction worldwide*

With all the talk of impending nuclear plant closures, advanced-reactor funding bills, used fuel management policy, and other such topics, there was no shortage of issues to discuss at the 2016 ANS Annual Meeting, held June 12–16 in New Orleans, La. The theme of the meeting was “Nuclear Power: Leading the Supply of Clean, Carbon Free Energy,” and it featured a number of special sessions on the above trending topics, plus more than 50 technical sessions and two embedded topical meetings: Advances in Thermal Hydraulics 2016 (ATH ’16) (see page 120) and Nuclear Fuels and Structural Materials 2016 (NFSM 2016) (see page 123).

In introductory remarks at the opening plenary session, outgoing ANS President Eugene Grecheck characterized his tenure at the society’s helm as having been “an interesting time.” “This year has been one of those cases of two steps forward and one step—or however many steps—back, as we try to apply nuclear toward world problems,” he said. One major step forward, according to Grecheck, occurred in late 2015, when ANS and some 150 partner organizations from around the world, through the Nuclear for Climate initiative, made their presence known at the United Nations’ COP21 climate change conference in Paris (*NN*, Jan. 2016, p. 34).

“Prior to COP21, nuclear was specifically excluded as a carbon control strategy for countries to use,” Grecheck said. “That policy has now been removed from the United Nations’ structure. And while we can’t take sole credit for that outcome, I can tell you that if we hadn’t been there, and if we hadn’t been very actively working behind the scenes with government officials in creating visibility for nuclear

leading up to the conference, there may have been a different result. There certainly were people there who wanted a different result. So, for the first time in some 15 years, nuclear is now being recognized as a valid carbon control/reduction strategy.”



Grecheck

As other examples of forward steps, Grecheck pointed to two nuclear-themed Washington summits—one in November of last year on advanced reactors and nuclear’s role in carbon reduction (*NN*, Dec. 2015, p. 17), and one in May of this year on maintaining the current U.S. reactor fleet (*NN*, July 2016, p. 38). “All of this very favorable news about the future for nuclear has been occurring for a very short time—less than a year,” Grecheck said. “ANS and our partner organizations have been making important connections with many people in the government and the agencies, as well as the White House, and getting real results.”

Recent backward steps for nuclear, Grecheck continued, include Omaha Public Power District’s decision to close Fort Calhoun and Exelon’s announcement that it would begin the shutdown process at Clinton and Quad Cities. “These are, unfortunately, reminders that very serious challenges remain,” he said. “Artificially low fossil-fuel prices, primarily natural gas, and energy markets that just don’t value the clean-air benefits of nuclear have made it difficult for nuclear to compete economically in this country and around the world. . . . And make no mistake, short-term economic decisions, while pos-

sibly understandable, are being made that are not in the best long-term interest of the economy or the environment.”

As one means of combating this situation, Grecheck referenced the work of the ANS Special Committee on Nuclear in the States—established in 2015 to provide information to state policymakers on the benefits of new and existing nuclear power facilities—and its *Nuclear in the States Toolkit 2.0*, an update of the committee’s policy options publication originally released in February. (See page 116 for coverage of the special session on the committee and its activities). “I think the committee has done exemplary work to get to this point,” Grecheck said. “Now, the answer would be to take this information and make it available to the policymakers at all levels. That’s not something the committee can do all by itself. That is going to require the involvement of ANS members at all levels.”

Following Grecheck was Donna Jacobs, chief operating officer for Entergy Nuclear’s southern fleet and the meeting’s general chair, who introduced the plenary session’s three featured speakers: Christopher Bakken, executive vice president of nuclear operations and chief



Jacobs

nuclear officer at Entergy Nuclear; Sarah K. Mack, president and chief executive officer of New Orleans-based Tierra Resources, which provides advisory services on wetlands restoration; and Michelle Sanchez, a professor in the Department of Physics and Engineering Physics at Tulane University’s School of Science and Engineering and director of Tulane’s K-12 STEM (science, technology, engineering, and math) Outreach program.

Having recently returned from Europe, where he spent the last decade working for British Energy and EDF, Bakken declared that “the game in the United States has definitely changed, and we must overcome the challenge we now face.” Market flaws are placing high-performing nuclear units at risk of early retirement, he said, noting that despite the solid power generation performance of FitzPatrick and Pilgrim, Entergy made the decision to prematurely close those plants in 2017 and 2019, respectively, simply because the economics did not support their continued operation. “It’s a pretty somber situation for our industry,” Bakken said. “If a nuclear plant is shut down, it will more than likely be replaced with facilities that produce higher-cost electricity over the long term and provide only one-tenth of the jobs.”



Bakken

cymakers address the market issues that threaten the economic viability of even the most cost-effective nuclear power plants,” he said. “Unless prompt action is taken, more valuable energy assets could be at risk of shutting down. A diverse supply of fuels and technologies to generate electricity balances the benefits and risks associated with each source, including clean air, reliability, and economics. Nuclear energy plays an important role in the diverse generating mix, and it’s critical to our global efforts to reduce greenhouse gases.”

Next to speak was environmental scientist Mack, who spoke about her firm’s wetlands restoration projects and how nuclear energy, as a low-carbon energy source, contributes to that work. “I think it’s really easy for us to talk about what the impacts of climate change could be, but when I was 28, I actually witnessed what those impacts are with Hurricane Katrina,” Mack said. “Eighty percent of the state flooded. . . . When we started to rebuild, we



Mack

wanted to look at the lessons learned from the storm. One of the biggest lessons learned was the benefit of wetland systems. We found that the levee systems that maintained had wetlands in front of them, whereas the levee systems that failed had open water in front of them. . . . We’re not going to exist in the future, either in this city or in this region, without our wetlands, which, by the way, are one of the most carbon-sequestering ecosystems. Louisiana faces some of the highest rates of wetlands loss in the world, occurring at the rate of one football field every hour.”

According to Mack, success with wetlands restoration will depend to a great extent on whether the world is able to limit the increase in global average temperature to less than 2°C—the goal of the COP21 agreement. “We can

By undervaluing nuclear power plants, Bakken continued, current market policies and practices threaten the diversity of the country’s generating portfolio and its ability to meet environmental goals.

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move forward with innovative restoration techniques, but if those temperature increases go beyond 2 degrees, the southern third of Louisiana goes underwater up to six feet,” Mack said. “Nuclear is helping to stem emissions to help control increased temperatures to 2 degrees. So wherever you’re working, whatever plant you’re working at, what you do has far-reaching impact for the world. As for us, we cannot save ourselves and work on our wetland restoration impacts and be successful here unless you’re successful at what you do.”

Tulane’s Sanchez, the session’s final speaker, focused on the importance of providing STEM education to grades kindergarten through 12. The need for promoting STEM careers is well documented,



Sanchez

she said, noting that by 2024, the number of STEM jobs in the United States will have expanded by 17 percent from 2014, whereas non-STEM positions will have expanded only by 12 percent. Within the STEM field, she added, engineering will have grown by 12 percent, advanced manufacturing by 16 percent, and computing by 19 percent. Sanchez also noted that half of all STEM jobs do not require a four-year degree, yet still pay, on average, 10 percent more than non-STEM jobs with a bachelor’s degree.

“There are a lot of students who might not be capable of a four-year degree but who still can earn a good living by going into a STEM field,” she said. “Our job is not only to promote STEM to the really bright students, but also to students who might not be pursuing the normal undergraduate-and-beyond route.” In addition, Sanchez said, the U.S. unemployment rate for STEM jobs is only 3 percent, compared to a rate of more than 7 percent for non-STEM jobs, and the statistic for Louisiana is even lower. “If you look at Louisiana, it’s 2 percent unemployment for STEM jobs,” she said. “It’s unbelievable—

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to think that virtually anybody with some sort of STEM background can get a job in Louisiana when they finish their education. . . . This is why exposing students at

an early age to science, technology, engineering, and math is so important.”

Sanchez described one particular STEM effort by 26 states to collaborate on common, next-generation content standards in science education for K–12 students that will incorporate, among other things, engineering design components. “These kids are going to start writing about engineering in kindergarten,” she said. “The hope is that by doing this, students will be able to see that science and engineering are instrumental in addressing the major challenges that confront society today.”

Sanchez also outlined Tulane’s K–12 STEM education programs, including the Tulane Science Scholars Program and Girls in STEM at Tulane (GIST). The scholars program provides opportunities for talented students in grades 10 through 12 to earn course credits at the university during the summer, prior to high school graduation. This year, according to Sanchez, the program expected to host students from 16 different states and seven students from outside of the country. “Many of the students who participate in this program during the summer are thinking about Tulane as a possible college choice,” she said. “It’s a way for them to experience college before high school graduation. We have a variety of classes, including electronics, materials science, chemical engineering, and computer science. These are very hands-on courses, very lab-heavy, so they can see what it’s like to major in a STEM field and what their career could be like later on as a scientist or engineer.”

The school’s GIST program, Sanchez explained, is designed for girls in grades five through eight, providing them with the opportunity to meet and work with female role models in STEM fields. “They come and spend a Saturday with us at Tulane,” Sanchez said. “We take them through the science and engineering labs to do experiments and hands-on activities, where they get to work with Tulane faculty, as well as graduate and undergraduate students. We have over 100 volunteers on any given day, which I think is amazing. . . . Spending the day with other students who think science is cool can help them see that it *is* cool and can motivate them to take further classes when they reach high school. We will be starting a boys program this fall as well.”

Sanchez also mentioned a number of national and regional programs that Tulane is involved with, including the Perry Initiative, a program for high school girls designed to increase their awareness of the fields of engineering and orthopedic surgery; the American Institute of Chemical Engineers’ High School Outreach Program, which exposes middle school and high school students to the chemical engineering profession and to engineering in general; and the FIRST (For Inspiration

and Recognition of Science and Technology) Robotics Competition.

“FIRST increases the number of students who are interested in STEM, creates leaders, and teaches such skills as teamwork, problem solving, critical thinking, and communication,” Sanchez said. “The impact this program has on students is unbelievable. If a student participates in FIRST, they’re two times more likely to major in science and engineering. And FIRST provides scholarships to students who participate in the high school competitions.”

Preserving the fleet

The general chair of the Annual Meeting, Entergy’s Donna Jacobs, took on the issue that is currently causing the nuclear industry the most concern—early plant closures—with a special session titled “Improving the Competitiveness of the Existing U.S. Commercial Nuclear Fleet—Sustaining a National Asset.” Featured speakers included William Mohl, president of Entergy Wholesale Commodities; Peter Lyons, former Department of Energy assistant secretary for nuclear energy; Anthony Pietrangelo, senior vice president and chief nuclear officer at the Nuclear Energy Institute; and William Webster, executive vice president for industry strategy at the Institute of



Jacobs

Nuclear Power Operations. Jacobs began the session on a positive note, pointing out that nuclear energy produces about two-thirds of all carbon-free electricity in the United States, three times more than hydro and nearly five times more than wind. She also pointed out some recent good news for nuclear, including the connection to the grid of Watts Bar-2, the construction of new reactors at Vogtle and Summer, and the recent application by the Tennessee Valley Authority to site small modular reactors at the Clinch River site in Tennessee.

“Sadly, however, many existing plants are shutting down prematurely, challenged by low commodity prices and competitive-market imbalances,” Jacobs said. “These include Kewaunee, San Onofre, Crystal River, and Entergy’s own Vermont Yankee. Upcoming shutdowns, those that have been announced, include Clinton, Quad Cities, Oyster Creek, Fort

Calhoun, and Entergy’s own FitzPatrick and Pilgrim stations. These plant shutdowns are a cause for concern, not only for the existing fleet of nuclear reactors, but for the nuclear industry as a whole. . . . My challenge to you is to take this session as a call to action. Listen to the challenges we’re facing right now. Seek to understand how these plant shutdowns impact what you currently do. Envision a future where there is no nuclear power. And then, think about what you can do, starting today, to change the course we are currently on.”

Entergy’s Mohl reminded the audience that about half of U.S. nuclear plants are in unregulated merchant markets and at risk of premature shutdown, especially

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single-unit plants. These facilities currently receive about 80 to 85 percent of their revenues from energy prices, he said, and about 15 percent from capacity prices—statistics that indicate how important the price of natural gas is to nuclear sustainability. “We’re now dealing with a market that has \$2 to \$3 gas,” Mohl said. “Some months it’s below \$2, some days it’s below \$1, depending on where you’re located. . . . We can’t control the price of natural gas. But what we can impact is some of the policies that we have across the markets and



Mohl

across the country. Quite frankly, we’re not seeing enough movement from an energy policy perspective in addressing this issue.” The current price of natural gas, Mohl continued, has resulted in significant gaps between operating costs and revenues, with costs in the \$50 to \$55 per megawatt-hour range and revenue streams of \$25 to \$35 per megawatt-hour—an unsustainable state of affairs in the long term. According to Mohl, if all of the announced plant shutdowns occur, CO₂ output will increase by about 44 million tons per year. “That’s based on replacing it with a new-technology, combined-cycle unit, not to mention that we’re losing a baseload, fuel-diverse resource for the nation’s energy portfolio,” he said. “We are shutting down plants right

now that often are a much more economical alternative to new-build resources. And why is that? It's because the attributes of these facilities are not properly valued, and there are problems with the inherent market design for pricing of capacity and energy in these wholesale markets."

In Mohl's view, these markets lack the ability to focus on the long-term policy objectives of economic sustainability for the customer and investor, environmental sustainability, and reliability. "It's tough to make investment decisions when you're dealing in markets that are based on the short term and don't consider the long-term objectives," he said. "No one is taking any responsibility for setting policy to make sure that we have more of a balanced market and that we're valuing the attributes of all generators, not just renewables or gas-fired resources, but baseload nuclear plants. . . . What we do now is run plants out of business and replace them with new-build plants. Those new-build plants will actually be an increase to the customer cost. You'll also see an increase in the volatility on customers' bills."

Entergy has pushed for market reforms that would level out costs by properly compensating power generators for the attributes they provide, Mohl said, including, in the case of nuclear, baseload energy/price stabilization, effectively zero greenhouse gas emissions, on-site fuel supply, and voltage support. "The solution is to revisit the market and put a value on the various attributes and make sure you're in line with long-term objectives," Mohl said. "In this country, we're moving to a point where reserve margins are very, very thin. We're getting closer and closer to the point of potentially having reliability issues, especially if we start removing key, baseload nuclear plants."

In closing, Mohl recommended a number of specific actions to address the problem, including the following:

- The Federal Energy Regulatory Commission should fix energy price-formation issues that artificially suppress day-ahead prices, eliminate all uplifts, and protect energy and capacity markets from the negative economic impacts of out-of-market subsidies.

- Independent system operators should place a value on ancillary service benefits or attributes of nuclear generation.

- States should place a value on carbon reduction and implement market-based, technology-neutral programs to compensate resources.

Next, Pete Lyons provided a progress report on the ANS Special Committee on Nuclear in the States, which he co-chairs with Donald Hoffman. The committee was formed last year and charged with identifying and reviewing state and

regional opportunities for new U.S. nuclear development, state-level legislative and regulatory barriers preventing such development, federal policies that have a direct impact on state-level decision-making, and lessons learned from the new nuclear projects under construction. According to Lyons, however, that initial mission was quickly augmented following the committee's first meeting.



Lyons nuclear projects under construction. According to Lyons, however, that initial mission was quickly augmented following the committee's first meeting.

"The committee agreed immediately that one really couldn't focus on how wonderful it would be to create a market for new plants when the existing plants were closing around us," he said. "We were running the risk of undermining and maybe even losing a key industry. It doesn't do much good to talk about new plants if the industry that they're going to support is going away. So we proposed to [ANS] President Grecheck that we broaden the charter of the committee and add a very strong focus on maintaining the current fleet. That is where a significant fraction, probably the largest fraction, of our effort has been invested over the last year."

Among the tasks the committee agreed to undertake, Lyons noted, were reviewing the Environmental Protection Agency's Clean Power Plan, developing a toolkit of state actions to appropriately value nuclear energy, working with each state to implement a state-specific plan for nuclear, developing a report outlining the impact on the United States of no nuclear power, developing state infographics to inform policymakers of their state's benefits from nuclear, developing case studies on the effects of nuclear plant closures and evaluating methods of state compliance with the Clean Power Plan, meeting with the EPA to suggest changes in the plan to value clean baseload energy, and talking with governors and policymakers in states where nuclear is threatened. Some of these actions have been taken and products produced—including the *Nuclear in the States Toolkit*, the *U.S. Without Nuclear Energy* report, and *The Clean Power Plan: Impact on the U.S. Nuclear Energy Industry and Analysis of Major Issues*—while others are still in progress, according to Lyons. "As we look into the next year, our focus will be on working with states for which the assets are threatened—trying to involve ANS lo-

cal sections, other opinion leaders in the state, utility leaders within the state, and trying to give them tools they can use to work with their leadership."

In his comments on the Clean Power Plan, Lyons was not kind, criticizing the plan for its concept of "leakage"—whereby states could theoretically remain in compliance while actually increasing carbon emissions—and its failure to include existing low-carbon sources, such as nuclear, in its compliance policy. "Why aren't the existing plants counted?" Lyons asked. "Well, the direct quote from the EPA is, 'On further consideration, we believe it is inappropriate to base the BSER [best system of emission reduction] on elements that will not reduce CO₂ emissions from effective EGUs [electric generating units] below their current levels. Existing nuclear generation helps make existing CO₂ emissions lower than they would be otherwise, but they will not further lower CO₂ emissions below the current level.'

"That kind of reasoning makes sense and is defensible only if they can be as-

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sured that those nuclear plants are going to continue to operate under 'business as usual,'" Lyons said. "It completely discounts the fact that when any of the utilities start going into renewal proceedings or license extensions on plants, that's a big deal. There is a lot of cost involved. And there is no guarantee that utilities are going to seek those license extensions, especially in the current market. Furthermore, we've got plants closing that have license extensions. So to me, the EPA's reasoning is flawed, to put it mildly. . . . It's nice to talk about how wonderful the Clean Power Plan is for cutting emissions. The fact is, it isn't. And it's not accomplishing what it was stated to accomplish."

NEI's Pietrangelo spoke on the industry's Delivering the Nuclear Promise initiative, a three-year program whose goals include enhancing the levels of safety and reliability at nuclear plants, identifying opportunities and redesigning fundamental plant processes to improve efficiency and effectiveness, using innovative technology to increase efficiency across the industry, and educating and driving awareness of nuclear energy's value, particularly its economic and environmental benefits.

Continued

“We’re making progress in getting that story out, but it’s slow progress,” Pietrangelo said. “We’ve got economic challenges—flat demand, marginal growth, low-cost natural gas, subsidized wind and solar. We’ve got flawed markets.

The objective of the Delivering the Nuclear Promise initiative is to reduce total generation costs 30 percent by 2018, largely through process efficiency.

We bear a heavy regulatory burden in our industry from the Nuclear Regulatory Commission. . . . We’ve witnessed generating costs at U.S. nuclear plants increase about 28 percent over the last 10 years or so. Trying to do a ‘business as usual’ approach to incrementally address this problem isn’t going to get it done when you have rising cost challenges and inadequate value in the markets. Something’s got to give.”

The overall governance and oversight of Delivering the Nuclear Promise, according to Pietrangelo, is provided by industry chief executive officers and the boards of directors at NEI, the Institute of Nuclear Power Operations, and the Electric Power Research Institute, while its operation is led by a steering committee of industry chief nuclear officers and



Pietrangelo

other senior representatives. The committee has also established the structure, priorities, and accountabilities for the initiative, he said, and CNO-led teams are proposing improvement opportunities and recommended levels of industry accountability to the steering committee. Once approved, these opportunities are transmitted to nuclear plant operators via NEI Efficiency Bulletins, which are color coded to indicate their degree of importance. The industry has issued 14 bulletins to date in 2016, Pietrangelo said, with 25 more scheduled for completion this year.

“We’re going to track completion of all of these bulletins,” Pietrangelo said. “We have what we call a ‘bingo chart,’ where we list all the plants on one axis, and all the efficiency bulletins down the other, and then we ask people to report when they’re done. We’re going to show that chart to the CNOs in every meeting that they have. We’re going to show it to our board, and INPO is going to show it to its board, in order to track who is getting what done

and when. That is our accountability mechanism, peer-to-peer.”

INPO’s Webster also discussed the Delivering the Nuclear Promise initiative, beginning his presentation with a series of PowerPoint slides showing that nuclear

plant operational performance reached all-time high levels in 2015 in nearly all categories measured by INPO, including unit capability factor, forced loss rate, forced loss events, unplanned manual and

automatic scrams, safety system performance, and collective radiation exposure. (The one exception, fuel performance, was down slightly in 2015 from the previous year.) Nonetheless, Webster said, operational performance improvement alone cannot meet the economic challenges currently facing the industry. “If we look at Quad Cities, Clinton, Fort Calhoun since the recovery from the flood, FitzPatrick since the replacement of the condensers, Oyster



Webster

Creek, Pilgrim, we can’t ask them to perform better operationally. It really comes down now to the need to work on the cost side, in a way that we, as an industry, haven’t done before.” The objective of the Delivering the Nuclear Promise initiative, Webster said, is to reduce total generation costs 30 percent by 2018, largely through process efficiency. “The part in which I’ve been most involved is really the streamlining processes,” he said. “At the end of the day, most every process, with the exception of security, in some way has an INPO guideline, an INPO good practice, an INPO principles document—something that governs the way that activity is conducted at the site. We need to streamline these processes, while making sure that the INPO guidance is consistent with, and in many cases leads, the changes that occur.”

Areas of focus for efficiency improvements, Webster said, include work management and maintenance, corrective action programs, training, oversight, engineering, radiation protection, and supply chain. Regarding maintenance, he said that the initiative has a team that has been “given almost free rein to think—almost a blank sheet of paper—about how you ought to maintain a plant. This team went out and benchmarked several high-reliability organizations outside of nuclear, such as Dow Chemical. Not ev-

erybody does maintenance quite like we do, if you can imagine that—how they organize and how they integrate engineering, who develops the packages for maintenance that’s done, what their balance of preventive maintenance versus corrective maintenance is, how they do condition monitoring, etc. This team is really coming up with some very creative and almost radical changes as to how we ought to approach maintenance.”

In the question-and-answer period following the presentations, Jacobs asked each speaker to identify something that audience members could do to help the industry deal with its current challenges, and all advocated for more engagement. Pietrangelo said, “We have to become more offensive rather than defensive. As an industry, we tend to lead with our problems, whether it’s used fuel or safety issues. It’s a tough change. I’ve been in this for 37 years, and safety has been the number-one thing. That’s what we always talk about. To the public, however, when you’re talking about it all the time, they think there must be something wrong with the industry. We’ve got to change, and I think you’ll start to see that soon.”

Licensing beyond LWRs

The title of the President’s Special Session was “Beyond the Hype: What’s Next for Advanced Reactors?” Outgoing ANS President Eugene Grecheck introduced the session’s six speakers: John Herczeg, deputy assistant secretary for fuel cycle technologies at the Department of Energy; Kemal Pasamehmetoglu, associate director of Idaho National Laboratory and director of the DOE’s recently established Gateway for Accelerated Innovation in Nuclear (GAIN); Andrew Sowder, principal technical leader at the Electric Power Research Institute; Jeffrey Merrifield, a partner in the Pillsbury law firm and a former member of the Nuclear Regulatory Commission; and Ben Reinke, the current ANS congressional fellow, who has been assigned to the Senate Energy and Natural Resources Committee.

Pasamehmetoglu led off the session with the news that the DOE had just awarded \$82 million for projects and



Pasamehmetoglu

educational support in advanced nuclear technology (NN, July 2016, p. 22). He later pointed out that GAIN is not a separate program, but more of an organizing principle for backing new systems and initiatives. One aspect of the many recent discussions of

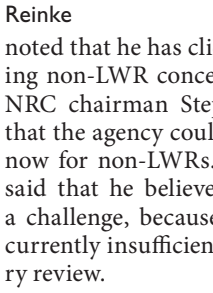
such systems (including during a workshop held by the DOE and the NRC the previous week in Washington, D.C.) is that it seems to be necessary to refer to these concepts categorically in terms of what they are not: large light-water power reactors of the kinds operating in the United States today. Because of these concepts' wide variety of fuels, coolants, and system architectures, and the common use of "advanced reactors" to refer to the Generation III/III+ LWRs now being built around the world, the truly innovative designs are lately being referred to as "non-LWRs."

Sowder was asked why EPRI, which is supported by utilities concerned mainly with the equipment they have now (such as large LWRs), would devote some of its



Sowder

attention (and thus some of its backers' money) to advanced reactors. He replied that utilities see uncertainties in the long-term prospects for their existing reactors and are looking to other options. Among other things, the national LWR fleet that is essentially fully baseloaded may try to adapt the load-following capabilities that could be employed in some advanced reactors. Reinke and others discussed the progress made on some legislation, the most significant aspects of which (including developments that occurred after this session) have been reported in the news sections of this issue of *Nuclear News*.



Reinke

Merrifield, who noted that he has clients who are developing non-LWR concepts, said that current NRC chairman Stephen Burns has said that the agency could receive applications now for non-LWRs. Merrifield, however, said that he believes that this would be a challenge, because source term data is currently insufficient to support regulatory review.



Merrifield

The discussion later turned to molten salt reactors and their declared advantages, such as inherent safety from catastrophic accidents, along with fuel dissolved in salt rather than confined in fixed assemblies. Herczeg asked Mer-

rifield if he would have licensed fluid fuels during his time as a commissioner (1998–



Herczeg

2007), and Merrifield acknowledged that this would have been "a challenge." Pasamehmetoglu noted that all modeling so far is based on stationary fuel. Grecheck asked whether modeling for fluid fuel could be done using the Oak Ridge National Laboratory super-computer facilities available through CASL, which, as is indicated by its full name—the Consortium for Advanced Simulation of Light Water Reactors—was set up chiefly to support LWRs. Pasamehmetoglu replied that the right data would be needed for validation, and there would have to be some agreement on this from the NRC.

From the audience came the question of why advanced reactor development is limited mainly to federal money. The general response was that basic research and development in many fields is led by the public sphere. Merrifield noted that nuclear is not unique in this respect, with a great deal of the advancements in aircraft and computers having come from military R&D. Sowder said that fuel vendors cannot take on the full risk of the development of accident-tolerant fuel.

Asked what is missing in the development infrastructure, Pasamehmetoglu mentioned fast-spectrum irradiation capability, which is currently available only in Russia. The DOE is looking at acquiring capability, and this might be necessary for the United States to gain world leadership. Merrifield lamented the closure of the Fast Flux Test Facility, which originally was linked to the liquid-metal fast breeder reactor program but is potentially applicable to other advanced reactor concepts. Discussion on the concepts' fuel cycles led Herczeg to note that it might be possible to treat fluid fuel like a spent fuel reprocessing plant, which can be licensed now.

Merrifield asked whether higher enrichment would be reasonable. Herczeg said that anything higher than 19.9 percent of uranium-235 (or whatever fissile materials are used) would be outside what is currently considered the acceptable range for nonproliferation, although if fuel enriched above 20 percent were, by a reactor's design, kept in the reactor for several years, proliferation concerns might be averted. There was a proposal of the term

medium-enriched uranium for fuel in the range of up to about 27 percent, which would be useful for fast-neutron reactors.

On the question of whether the Nuclear Waste Policy Act should be rethought to make actinide burning possible, Herczeg said that under the current policy, the consent-based approach to repository siting will be pursued. Pasamehmetoglu said that spent fuel should not be an afterthought in the development of advanced reactors, and that the current approach to spent fuel management would not be available for advanced reactors.

Grecheck closed the session by asking the other panelists what has to change in order to make advanced reactors a reality. Herczeg said that more than just money is needed, calling for the public to be educated and for the private sector to be engaged to build demonstration units of models such as gas-cooled reactors or General Electric's PRISM. The policy must also accept financial risk. Merrifield called for changes to investment tax credits to put nuclear on an equal footing with other sources, a push for the most quickly deployable concepts, and some fixes to the back end of the fuel cycle.

The public should be allowed to get closer to reactors and thus feel less threatened by them, and small modular reactors could make this possible.

Pasamehmetoglu agreed on investment tax credits, but he also wants greater value placed on what nuclear can provide to the electricity system right now, such as grid stability. He also said that the public should be allowed to get closer to reactors and thus feel less threatened by them, and suggested that small modular reactors could make this possible. Sowder said that developers should have the opportunity to fail quickly with many concepts, cheaply, so that it would be possible to determine soon which concepts are viable. Reinke said that he would like to see the end of production tax credits for wind energy, with that money devoted to energy R&D in general, not just nuclear. He also called on all nuclear professionals to help teach everyone else about nuclear.

Influencing state policy

The ANS Special Committee on Nuclear in the States was the subject of a special session organized and moderated by Donald Hoffman, president and chief executive officer of EXCEL Services Corporation and an ANS past president (2013–2014), who cochairs the committee

along with former Department of Energy official Peter Lyons (see page 113 for Lyons' comments on the committee). The session featured presentations by three committee members: C. J. Milmoie, president of Milmoie Consulting Services; Daniel Curtis, a graduate student and research assistant at the Massachusetts Institute of Technology; and Nicholas Thompson, a graduate student at Rensselaer Polytechnic Institute.

Hoffman kicked off the discussion by providing some background on the committee and a summary of its activities over the past year, which have been directed toward two major goals: maintaining the current nuclear fleet and supporting new nuclear build. After noting the early-closure announce-



Hoffman

ments for Pilgrim, FitzPatrick, Clinton, Quad Cities, and Fort Calhoun—the re-

any other clean energy standard,” he said. “Many of the states were already embarking on clean energy standards or other activities to reduce carbon emissions, irrespective of whether or not they were going to be consistent with the CPP. We utilized that as a leverage point to get engaged and involved with state legislatures and their activities. We recognized that in order to be successful, we needed to roll out a number of products that would enable us to demonstrate that we had the wherewithal to speak intelligently about this issue and to go into state officials’ offices and tell them what we thought they should do and what kind of information they needed to make informed decisions. We went to the governors’ offices and sat down with them and their staffs to talk about what nuclear is, what its value is, and how we can assist them in making sure that their nuclear plants are appropriately valued and engaged in the clean energy standards, and we were very well received.”

Also well received, Hoffman said, was the committee’s first product, the *Nuclear in the States Toolkit*, the initial version of which was rolled out in February of this year. (A second, “2.0” version of the toolkit was unveiled at the meeting.) A 40-page publication, the toolkit contains policy options for those states mulling a role for nuclear in their energy mix. The toolkit was followed by *The U.S. Without Nuclear Energy: A Report on the Public Impact of Plant Closures*, a 13-page publication that debuted in April at the International Congress on Advances in Nuclear Power Plants. The committee has also created infographics for California, Massachusetts, and New York policymakers to inform them of the benefits of nuclear energy, and it intends to do the same for other states.

“We are going to personally be visiting the governor and staffs of each of those states where nuclear is most threatened,” Hoffman said. So far, the committee has met with the governors, and/or their staffs, of Maryland, New Jersey, New York, South Carolina, and Virginia, and is now turning its focus to California, Illinois, Massachusetts, Nebraska, and Ohio.

The committee has also made presentations to the National Governors Association, the National Association of State Energy Officials, the National Association of Regulatory Utility Commissioners, and the Republican Governors Association.

The committee also plans to meet with the EPA and congressional leaders in the

fall and with federal and state policy organizations throughout the year, Hoffman said. More publications are planned for this year as well, including *Case Studies on the Effects of Nuclear Plant Closures and Models of Emissions and Power Generation* and *Methods of Compliance with the Clean Power Plan*.

Hoffman noted that when presenting its case before policymakers, the committee stresses nuclear’s unique value, including that it is the only environmentally friendly baseload energy source and that the average nuclear facility generates approximately \$490 million in sales of goods and services, nearly \$46 million in total labor income, \$16 million to \$20 million in state and local tax revenue for schools, roads, and similar infrastructure, and 700 to 1,200 permanent jobs that pay 36 percent to 42 percent more than the average salaries in the region.

“Our plan is to halt premature shutdowns, lift plant moratoriums, revise the CPP, revise the electricity market, and make sure we get a level playing field for nuclear,” Hoffman said. “We’re trying to do something about every state that has a problem with nuclear plants, but there is an urgent need to develop policies that will prevent additional premature shutdowns. The fact is, the very underlying policy premise in this country is flawed. It does not enable clean energy sources to be appropriately valued at a time when they should be more valued than ever.”

Milmoie centered his remarks on the committee’s plant-closure impact report, which targets policymakers and influencers at the state level. “In ANS, we’re used to dealing at the national level, with the Nuclear Regulatory Commission and the DOE,” he said. “But the critical decisions that determine the fate of these plants facing tough times economically lie with the state regulators.”

The loss of nuclear as an energy source would have severe and widespread impacts, Milmoie said, both on the economy and the environment. Withdrawing nuclear from the U.S. energy mix could potentially result in annual losses of \$103 billion in the gross domestic product, \$9.9 billion in federal tax revenues, and \$2.2 billion in state tax revenues, he said. In addition, wholesale electricity rates could be 10 percent higher and retail rates about 6 percent higher, he said, with full-time job losses in the 475,000 range. He noted that the environmental impacts could include an



Milmoie

“Our intent is to provide a consistent, standard approach for each of the states in valuing nuclear energy as an asset in their efforts to comply with the Clean Power Plan or any other clean energy standard.”

sult, he said, of “severely flawed” electricity markets—Hoffman relayed a bit of breaking news, informing the audience of Exelon’s decision to close Nine Mile Point-1 and Ginna if the New York State Public Service Commission fails to approve the state’s proposed clean energy standard, with its nuclear-supporting zero-emission credits, by the end of September (see page 22). “As you can see,” he said, “we have a great deal of work ahead of us.”

The Special Committee on Nuclear in the States was established in September 2015, just one month after the Environmental Protection Agency issued the final version of the Clean Power Plan (CPP), which requires the 48 contiguous states (with the exception of Vermont) to reduce their carbon emissions by 32 percent from 2005 levels by 2030. According to Hoffman, the CPP provides little guidance on how to accomplish that reduction, hence the formation of the special committee.

“Our intent is to provide a consistent, standard approach for each of the states in valuing nuclear energy as an asset in their efforts to comply with the CPP or

annual increase in CO₂ emissions of 573 million tons, as well as an increase in a number of other pollutants.

"If states want to meet their carbon reduction objectives, they're going to have to retain nuclear, and perhaps even build new units," Milmoie said. "Power industry and many environmental experts agree that replacing nuclear with solar and wind will make service less reliable and more expensive. It would take a huge increase in solar and wind capacity, with their load capacity factors, to make up the quantity and reliability of nuclear capacity lost. . . . The bottom line is that no other form of electricity can replace nuclear power's record of low-cost, emissions-free, dispatchable, reliable energy production."

The session's final presenters, Curtis and Thompson, who were awarded Presidential Citations at the Annual Meeting for their contributions to the committee, delved into their analysis of the CPP and its impact on the U.S. nuclear industry.



Curtis

Curtis began with a brief overview of the CPP and its central goal, the reduction of CO₂ emissions from existing fossil fuel-fired electric generating units (EGU). He noted that the plan's "best system of emission reduction" (BSER) concept consists of three steps that states are being recommended to take in order to reduce emissions: (1) improve heat rate at affected coal-fired steam EGUs, (2) replace generation from coal-fired steam EGUs with generation from existing natural gas combined-cycle EGUs, and (3) replace generation from affected EGUs with new renewable energy-generating capacity—onshore wind, utility-scale solar, geothermal, and hydropower.

Other, non-BSER measures that can be taken, Curtis continued, include heat-rate improvements at affected EGUs other than coal, carbon capture and storage, switching to natural gas or biomass at affected EGUs, waste heat-to-energy conversion at EGUs, demand-side energy efficiency, and new or uprated nuclear generating capacity.

"So here is where we are," Curtis said, "a footnote in the 'other things you can do' narrative. The EPA's reasoning is that the existing nuclear plants have already contributed to reducing emissions. We are already part of the business-as-usual scenario. We don't need any help. We're already doing just fine. Now, if it were certain that all the nuclear plants in the country would keep on operating, if they were all profitable, economically sound, and were not un-

der any kind of threat, this reasoning might have worked. It is abundantly clear, however, that this is not correct. The underlying assumption here is wrong."

Curtis also discussed the concept of "leakage" in the CPP, termed "malicious compliance" by nuclear advocates. He noted that University of Tennessee graduate students Remy Devoe and Justin Knowles found in 2014 that it was possible for states to comply with the CPP while increasing real emissions. "Devoe and Knowles deserve a lot of credit for helping to raise awareness of the fact that in the plan, only emissions from existing fossil units are counted, not new ones," Curtis said. "If generation from a nuclear facility is replaced by new fossil fuel-fired plants, you can tally up emissions under the CPP accounting for existing plants and show that emissions look like they're going down and that you're in compliance, while real emissions, when you tally up everything, including new units, are going up. This is perfectly allowable under the rule. Nick and I have gone through state-specific case studies to demonstrate that this can happen."

Thompson offered a review of multiple-scenario case studies showing the CPP's likely impact in Massachusetts, New York, Illinois, and Georgia. The scenarios included replacing coal with existing natural gas combined-cycle facilities, building a 1-GW nuclear energy facility, and replacing coal and nuclear with new natural gas combined-cycle facilities.



Thompson

We also know that because of the CPP, Massachusetts will probably shut down some coal as well. In that scenario, what actually ends up happening is that emissions go up. New York is a very similar example. There is actually less coal in New York than in Massachusetts, but there is a pretty large amount of natural gas and nuclear. We've been able to show that if you shut down just FitzPatrick and some coal, total emissions will go up in New York state."

Used nuclear fuel

The management of used nuclear fuel encompasses many technical, social, and political aspects. Questions of interim and long-term storage, transportation, and recycling and reprocessing need to be worked out among many parties. Some of these issues were explored during the technical program chair's special session, "Developing a Policy for Used Nuclear Fuel that Will Encourage an Expansion of Nuclear Energy as a Leading Supply of Clean Carbon-Free Energy."

Everett Redmond, senior director for fuel cycle and technical policy for the Nuclear Energy Institute, began the session with an overview of events related to used fuel management, providing a glimpse at where we are and how we got here. Noting that more than 76,000 metric tons of commercial used nuclear fuel is current-

While the restart of the Yucca Mountain licensing process, the elimination of the NWF fee, and the release of the safety evaluation report are notable steps toward a used fuel management solution, significant work still needs to be done.

ly in wet and dry storage in the United States, with 14 shutdown power reactors and more coming, he mentioned the 2010 decision by the Obama administration to suspend the Yucca Mountain repository program, which was followed by the 2013 federal court order to the Nuclear Regulatory Commission to restart the licensing process. The suspension of the Nuclear



Redmond

Waste Fund (NWF) fee in 2014 and the release of the Yucca Mountain safety evaluation report in 2015 were also notable milestones, he said. While the restart of the Yucca Mountain licensing process, the elimination of the NWF fee, and the release of the safety evaluation report are notable steps toward a used fuel management solution, Redmond said, significant work still needs to be done, including the adjudication of the hundreds of challenges filed against Yucca Mountain. The inability to manage the nation's used fuel is costing both ratepayers, who have contributed to the NWF, and taxpayers, who are covering the cost

of the Department of Energy's failure to take possession of the fuel under the Nuclear Waste Policy Act (NWP). Those breach-of-contract suits are paid out from the taxpayer-funded Judgment Fund, which Redmond said has paid out \$5.3 billion in NWP liabilities as of September 2015. The government's overall liability under the NWP is estimated to reach at least \$29 billion, Redmond said, but that figure, he added, is likely to rise.

Redmond said that it is the view of the nuclear industry that a new organization outside of the DOE, free from political influence, should be established to manage the nation's nuclear waste and that this organization should have access to the NWF. Redmond noted that there is bipartisan support in the Senate for moving forward on such legislation. Within the House of

A consolidated storage site would not be a substitute for geologic disposal but would provide a near-term solution for cost-effective radioactive waste management.

Representatives, however, there is a strong preference for maintaining Yucca Mountain as the sole geologic repository in any new legislation.

While Redmond addressed some of the incidents that have led to the United States' current situation, the next speaker, Andrew Griffith, associate deputy assistant secretary for fuel cycle technologies at the DOE's Office of Nuclear Energy, provided a look at where, as a nation, we want to go. Griffith began by admitting that the nation is facing a "daunting challenge" in



Griffith

trying to develop an integrated waste management program. Griffith discussed the DOE's current initiative to develop a consent-based process for siting facilities to store and dispose of used fuel and high-level radioactive waste. That initiative, launched in December 2015 (NN, Feb. 2016, p. 49), is based on the recommendations of the Blue Ribbon Commission on America's Nuclear Future. While the DOE's goal is to have a well-informed host community step forward and be willing to host a facility, Griffith admitted that the federal government, and in particular the DOE, has a "trust deficit" with the American public. He added, however, that there are

steps the DOE can take to move forward, and that any siting process needs to be phased and adaptive. "We have to build a process where we can learn as we go," he said.

Providing an industry perspective on consolidated storage of used fuel, Michael McMahon, senior vice president of Areva TN, gave an overview of Waste Control Specialists' (WCS) plan to build a consolidated interim storage facility at its site in Andrews County, Texas. Areva, along with NAC International, had assisted WCS in the development of its facility license application, which was submitted to the NRC on April 28 (NN, June 2016, p. 60).

McMahon noted that a consolidated storage site would not be a substitute for geologic disposal but would provide a near-term solution for cost-effective radioactive waste management. An interim storage site would remove barriers to developing a permanent repository by resolving public concerns and technical issues, as well as addressing possible license contentions in the near term, he said.

According to the timeline for the WCS project, the consolidated storage facility would be operational by 2021, McMahon said. It would be completed in phases, with the first phase involving the development of a pilot facility for dry cask storage of used fuel. The second phase would include a "full-scale" facility capable of receiving "bare" fuel and providing some repackaging services. Future stages would include an integrated waste management site with advanced research and development capabilities.



McMahon

In order to move forward, McMahon said, legislation is needed authorizing the DOE to take title of the used fuel and to use portions of the NWF for that purpose. In addition, he said, the DOE needs to embark on a major transportation initiative to meet the goal of opening the WCS facility in 2021.

As for the reprocessing and recycling of used fuel, William Burchill, retired head of the Nuclear Engineering Department at Texas A&M University and an ANS past president (2008–2009), gave the views of ANS. Burchill noted that ANS's policy position on fuel recycling was outlined in a *Nuclear News* article (NN, Feb. 2016, p. 42),

which in turn was based on ANS Position Statement 45 and its background material. In that position statement, ANS endorses an energy policy and legal framework for a U.S. nuclear fuel cycle program that includes both recycling and geologic disposal and the development of fuel recycling options in parallel with the development of advanced nuclear reactor systems.



Burchill

As for the economic benefits of a closed fuel cycle, Burchill said that the cost benefits were "ambiguous," but that it is important to keep future options open. The benefits of preserving and developing fuel cycle options, he said, include the stimulation of private investment and the preservation of knowledge and operational experience in the United States. A closed fuel cycle would also relieve used fuel storage limitations at commercial reactor sites, reduce the volume of waste needing to be disposed of in a geologic repository, reinvigorate important educational programs in separation technologies, and create new jobs, Burchill said. It would also give the United States a "place at the table" during international discussions on nonproliferation, he added.

The importance of having a seat at the international table was picked up by the panel's final speaker, Donald Hoffman, president and chief executive officer of EXCEL Services Corporation and an



Hoffman

ANS past president (2013–2014). Hoffman said that the United States is in jeopardy of losing its leadership position and needs to develop a closed fuel cycle program if it wants to remain influential and successful. One way the United States could lead, he said, is through the development of a program that would allow for the export of new nuclear fuel, which would then be accepted back into the United States for reprocessing.

New construction

The ANS Operations and Power Division has sponsored sessions on new reactor licensing and construction roughly since the resumption of licensing activity in the United States in the middle of the previous decade. Most often organized by Ted Quinn, of Technology Resources and an ANS past president (1998–1999), these

sessions have sometimes been scheduled as a division committee meeting and sometimes, as at this Annual Meeting, as a technical session in the main program.

While there were presentations on the actual construction and startup of plants based on fully developed reactor models, this installment of the session on new construction around the world led off with a presentation on reactor models still under development that in many cases depart from the basic principles of the large light-water reactors that make up the vast majority of reactors now in operation and under construction.

Thomas O'Connor, of the Office of Advanced Reactor Technologies in the



O'Connor

Department of Energy's Office of Nuclear Energy, was one of several speakers at the Annual Meeting who had participated in the second DOE-NRC workshop on ways to license and regulate nuclear energy systems that are not based on light-water reactors, held the previous week in Washington, D.C. In this session, O'Connor covered DOE activities in support of advanced reactor development. His "Vision and Goal" slide showed that the current goal is that by 2030, at least two advanced non-LWR concepts will "have reached technical maturity, demonstrated safety and economic benefits, and completed licensing reviews," allowing construction to go forward. The vision is that by 2050, "advanced reactors will provide a significant and growing component of the nuclear energy mix both domestically and globally." More specifically, O'Connor said that the DOE would aim for 200 GWe of nuclear energy installed in the United States by 2050.

O'Connor mentioned the DOE's two cost-shared projects with industry, announced last year, for more detailed exploratory work on the concepts for X-Energy's Xe-100 pebble bed gas-cooled reactor and a molten salt fast-neutron reactor from a team headed by Southern Company. The DOE could cover as much as 80 percent of the total cost, leaving the private-side partners responsible for providing about \$10 million. O'Connor stressed, however, that the choice of these two concepts is not viewed as "down-selection," putting these concepts ahead of all others (for instance, in a race to be one of the two concepts in the 2030 goal). He maintained that the designs meet the program's immediate goals and that the DOE "is not picking winners and losers."

An attendee asked why this effort was

not simply devoted to improving LWRs. Without digressing on the DOE's ongoing Light Water Reactor Sustainability Program, O'Connor said that the non-LWR work is addressing industry needs that might not otherwise be met. He stated that in his view, the inherent safety of concepts such as gas-cooled reactors has been generally affirmed.

A presentation on the construction and startup of reactors that are already taking on real-world existence was delivered by Everett Redmond, senior director for fuel cycle and technology policy at the Nuclear Energy Institute. His big-picture look at energy use showed that while global demand is expected to grow by about one-third from 2013 to 2040, about 1 percent per year on average, all of the net growth will come from countries outside of the Organization for Economic Cooperation and Development (OECD), essentially the "first world" industrial and market-driven countries. Within the OECD, demand could decline by 3 percent. In addition to his data on nuclear energy use and expansion in various countries (notably the 22 reactors under construction in China, with Russia's eight a distant second), he touched on the potential movement beyond LWRs. He said that the total of private capital committed so far to non-LWRs is \$1.3 billion, with more than 40 companies (both traditional and startups) involved in the United States and Canada.

Redmond called the goal cited by O'Connor, for two non-LWRs to be ready in the 2030 time frame, "challenging but doable." He noted that Southern Company, an electricity provider with Generation II reactors in operation and two Generation III+ reactors under construction, has set up its molten salt reactor venture for its "optionality." In keeping with the long view taken by many nuclear advocates, Redmond said that the time is critical to bring new nuclear energy concepts to practicality, with the likelihood of the retirement of many existing reactors by mid-century and the need to meet targets for reductions worldwide in greenhouse gas emissions.



Brister

The current goal is that by 2030, at least two advanced non-LWR concepts will "have reached technical maturity, demonstrated safety and economic benefits, and completed licensing reviews," allowing construction to go forward.

AECOM, described the new-construction readiness of his company. Due to a number of mergers and acquisitions, AECOM is able to declare its experience as architect, engineer, or constructor of 49 pow-

er reactors through its legacy companies (such as Dames & Moore, Ebasco, Gibbs & Hill, URS, and Washington Group). In his presentation on best practices for new construction, he addressed what he sees as the keys to success for the introduction of nuclear power into a country for the first time. These include international and bilateral agreements; a stable, independent, and reliable nuclear regulator; technical skills and infrastructure development; proven delivery program and partners; electricity market regulation; decommissioning; fuel cycle and back end management; and the role of the host government.

Art Wharton, a principal project manager at Westinghouse Electric Company,



Wharton

spoke informally about his company's activities, beyond the AP1000 projects already in advanced construction (four each in China and the United States). Some headway has recently been made on prospects for a six-reactor plant in India despite the country's liability law, which could allow claims for damages to extend to equipment suppliers. Wharton noted that the governments of India and the United States have agreed to move forward on the liability issue, and Westinghouse has recently expressed confidence that Nuclear Power Corporation of India Limited will formally commit to buying and building the AP1000s, perhaps later this year. Asked why the site for the project was changed from one state (Gujarat) to another (Andhra Pradesh), Wharton said that this decision was made by NPCIL.—E. Michael Blake, Tim Gregoire, and Michael McQueen