MECHANICAL
ENGINEERING
Technology that moves the world
THE MAGAZINE OF ASME
No. 07
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SPINNING LIQUID GOLD

CAN THE SHALE GAS BOOM TURN THE U.S. INTO AN ENERGY EXPORTER?

LOG ON ASME.ORG

SPORE POWER

THE SKIN OF A BACTERIAL SPORE IS A WRINKLY AFFAIR. Those folds help protect it from changes in humidity. With moisture in the air it smooths and expands; with dry air it wrinkles back up. Columbia University's Ozgur Sahin thought he might be able to harness the power of that wrinkling and unwrinkling. He put spores on a cantilever. With changes in humidity the spores did their thing, bent the cantilever, and produced an output.

PODCAST: ROBOTS TAKE ON MANUFACTURING

Rodney Brooks, the co-founder and CTO of Rethink Robotics, talks about the role robots will play in the nation's push toward advanced manufacturing.

VIDEO: THE NEW TAPPAN ZEE BRIDGE

ASME.org visits the construction site of a true engineering marvel: The new Tappan Zee Bridge, scheduled for completion in 2016.

SHOOTING LIKE A MACHINE

The **Dr. Dish Rebel** allows basketball players to have a machine to pass to them from 19 positions on the court in order to work on improving the arc of their shots.

For these articles and other content, visit **asme.org.**

NEXT MONTH ON ASME.ORG

UPSY-DAISY

Daughter of an engineer, Debby Elnatan explains the invention that helped her child with cerebral palsy achieve better mobility.

PODCAST: BREAKING BARRIERS IN 3-D PRINTING

Darrell Wallace, deputy director for advanced manufacturing enterprise at America Makes, the National Additive Manufacturing Innovation Institute, discusses barriers in 3-D printing.

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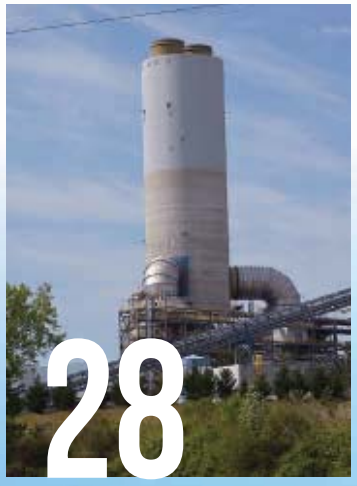

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***Give me the place to stand, and I shall move the earth*—Archimedes**

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John G. Falcioni
Editor-in-Chief

WORDS OVER NUMBERS NOT AN EVEN EXCHANGE

Imagine you're enjoying hors d'oeuvres and a drink at a cocktail party when the conversation turns to favorite magazines and newspapers, and the person you just met to your left says, "You know, I've never been very good at reading."

That would shock your senses. But what if, instead, the conversation turned to household spending and balancing the checkbook, and the person said: "You know, I've never been very good at math"? Somehow, that would seem a lot more acceptable to most of us.

The socially tolerated cognitive double standard is deep. That it's even acceptable is only because, at least in this country, we've come to believe that not having an aptitude for numbers is OK, but being illiterate is a far greater handicap. We've drawn a dubious line in the sand, and with a wink and a nod understand that it's fine to admit the failings of our capacity to learn the fundamentals of mathematics but not the basics of A, B, and C. Holding simultaneous contradictory values is what psychologists call cognitive dissonance.

Sure most of us can add, subtract, and multiply our way through most of life's arithmetic challenges, but ask us to balance the checkbook without our cell phone's calculator and many of us are lost. Or ask someone in the sixth grade to tell you how tall he is in inches and see how long it takes him to calculate the answer.

The anecdote about the cocktail party, although I paraphrased, was one of the intriguing notions discussed at the recent live taping of the ASME Decision Point Dialogues event on STEM education—*Critical Thinking, Critical Choices: What Really Matters in STEM*. The comment came from Pat Wingert, one of 12 Dialogues participants, who is a former *Newsweek* journalist and Spencer Fellow at Columbia University's Graduate School of Journalism. The focus of her year-long research project at Columbia was STEM education. Wingert now contributes to the Hechinger Institute on Education and the Media and has learned a lot about how kids in this country learn—or how poorly they learn STEM subjects in comparison to other countries.

Since the days of Manifest Destiny when as a country we held the strong belief that our mission was to spread our virtues and institutions across the continent, we've been proud of our educational system (and to a large measure we should be), so the fact that the STEM-related test scores of our kids pale in comparison with those of youngsters from such global powerhouses as Finland and Singapore really stings.

Momentum has gained in the Obama administration to get kids in the U.S. to be more inspired by science and math and to score higher on tests. But it hasn't been easy. The conflict points are huge and they have less to do with our kids' aptitude than with pure economics.

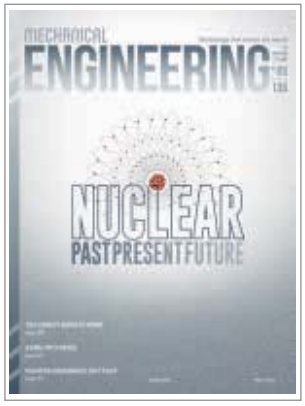
In this issue we include a roundup of the Decision Point Dialogues discussion among STEM thought leaders and moderator John Hockenberry, of public radio's program *The Takeaway*. To view the provocative broadcast visit **go.asme.org/dialogues**.

It may be a cultural uniqueness that we place more emphasis on words than numbers in this country, but the consequences run much deeper than our children's test scores—and this is no cocktail party joke. **ME**

FEEDBACK

Visit go.asme.org/STEMdialogues to tell us what you think about STEM education.

LETTERS & COMMENTS



MAY 2014

Reader Rosenberg sets the record straight on the Shippingport reactor vessel.

One reader says we shouldn't dismiss climate models. Another is concerned about the effects of junk science on society. And an ASME Past President sends in a correction.

DISCREDITED ON CLIMATE CHANGE?

To the Editor: I was surprised to see strong responses against Bill Nye's three lines on the politics of climate change (One-on-One, February) in letters published in the April issue of *Mechanical Engineering*.

One of those letters states, "There are many prominent true earth scientists who disagree with Mr. Nye, and as time goes on, many more are coming out of the woodwork."

A key phrase here is "earth scientist," which does not imply the same type of expertise as climate scientist. Within the climate science community, both parts of this statement are false. Survey articles published in *EOS* in 2009 and *Environmental Research Letters* in 2013 conclude that more than 97 percent of climate scientists active in the field agree that the Earth is undergoing anthropogenic global warming.

By viewing the Earth as a closed (but not isolated) system, the first law of thermodynamics and some radiation heat transfer are enough to understand that CO_2 gas can reduce outgoing radiation while leaving the incoming solar unchanged. The elementary scientific perspective is: Why should anthropogenic global warming not occur?

Global climate models have much in common with computational fluid dynamics models used in countless engineering applications. We should not be so dismissive of them.

Theory of anthropogenic global warming is supported by a huge and growing observational dataset. The loss of mountain glaciers, the losses of the Greenland ice sheet, and the rising oceans are obvious examples.

There is no longer much debate within the climate science community about whether or not anthropogenic global warming is real. Where the hard work now focuses is on getting the details honed. Climate change should be front and center for mechanical engineers because how we produce, distribute, and use energy is at the very core of this storm.

Joseph M. Prusa, *P.E., Boca Raton, Fla.*

EXPOSING JUNK SCIENCE

To the Editor: I was a bit surprised by the dissent expressed by engineers about Bill Nye's Q&A in the February issue. Bill Nye has a formal education in an applied science (engineering being the application of scientific principles). Collectively, his achievements demonstrate that he's qualified to speak on matters relating to science and technology. But at its core, the issue is less about Bill Nye and more about his message. More specifically, it's about an irrational denial of climate change, evolution, and a host of other topics where scientific consensus is overwhelming and public consensus is often marginal.

Clearly, he's demonstrated an ability to expose junk science and its effects on society—even within a community of engineers and scientists.

People like Bill Nye and Neil deGrasse Tyson, for example, play a vital role in trying to reverse a trend identified by Carl Sagan in his 1996 book, *The Demon-Haunted World*: "The dumbing down of America is most evident in the slow decay of substantive content in the enormously influential media, the 30 second sound bites (now down to 10 seconds or less), lowest common denominator programming, credulous presentations on pseudoscience and superstition, but especially a kind of celebration of ignorance."

Mike Redler, *Bridgewater, NJ*

CREDIT CHECK

To the Editor: I read "The Code Builders" (May) with interest. The article credits Babcock and Wilcox as the designers and fabricators of the Shippingport reactor vessel. This was not the case.

Admiral Rickover assigned the overall responsibility for the Shippingport reactor to the Bettis (Westinghouse) Atomic Power Laboratory. Cognizance of the reactor vessel was given to a very senior engineer by the name of Vernon Burton and to a less experienced engineer.

I was that latter person and can thus verify that the vessel was designed in detail by Combustion Engineering (not B&W) at their New York engineering office and fabricated at their Chattanooga facility.

Richard Rosenberg, *San Diego*

Note: *Rosenberg is an ASME Past President.*

FEEDBACK

Send us your letters and comments via hard copy or e-mail **memag@asme.org** *(use subject line "Letters and Comments").* Please include full name, address and phone number. We reserve the right to edit for clarity, style, and length. We regret that unpublished letters cannot be acknowledged or returned.

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WALKING WITH ROBOTIC HELP

RESEARCHERS IN GERMANY ARE PUTTING AN EXOSKELETON suit through its paces. Many paraplegic patients can use the Hybrid Assistive Limb robot suit to regain a certain degree of mobility and activity, though currently it's available only to those at about 150 Japanese medical institutions.

Now a research team at the Center for Neurorobotic Movement Training in Bochum, Germany, is testing the exoskeleton for launch in the German market.

The Hybrid Assistive Limb, or HAL, is a powered exoskeleton suit developed by the Sankai Lab at Tsukuba University in Japan. The lab's leader, Yoshiyuki Sankai, has formed Cyberdyne Inc. to market it.

Cyberdyne says the suit augments body movement and increases user strength by a factor of ten. The suit includes sensors that attach to the patient's skin to detect neural signals from the muscles and initiate a motion response in parts of the body.

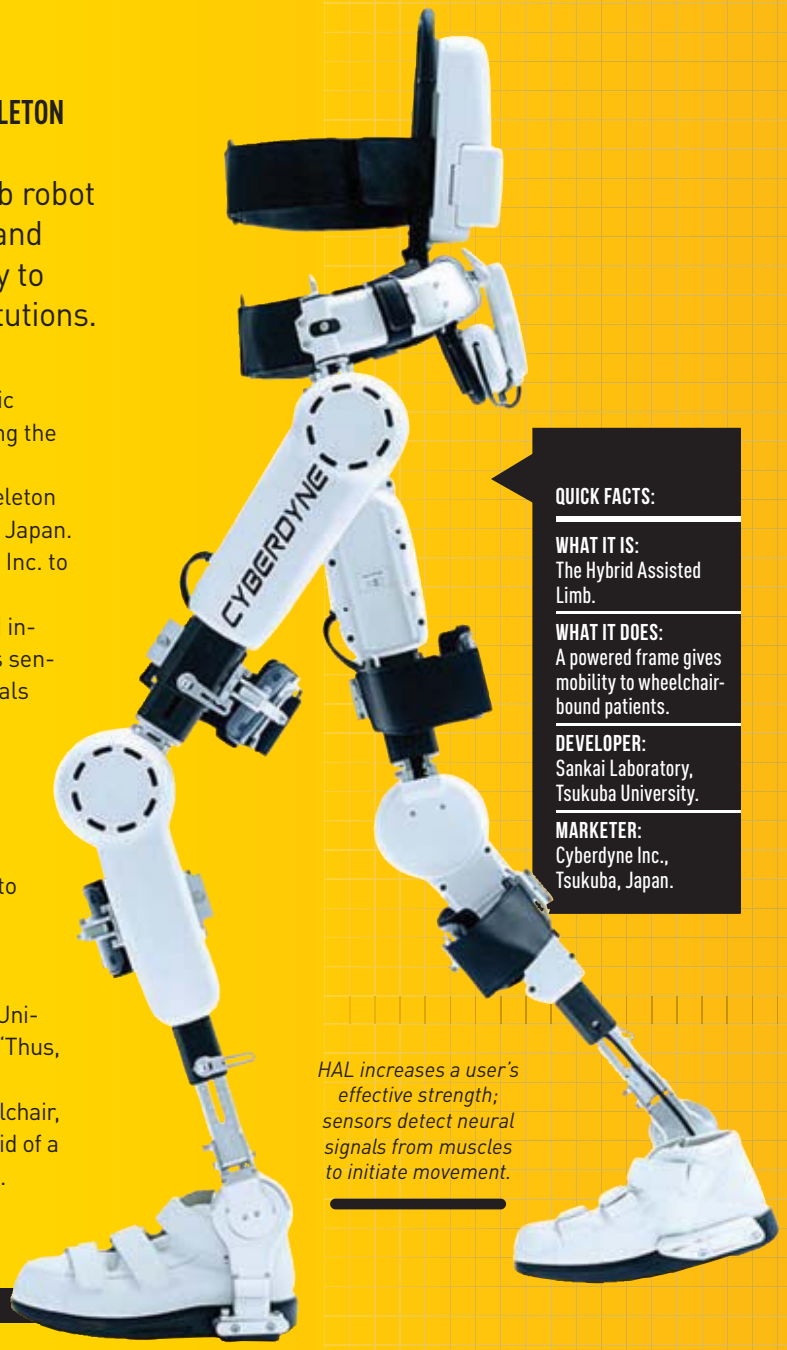
Cyberdyne has formed a subsidiary to market the suit in Germany, but insurance companies there won't cover the use of HAL until well-founded data is available. That necessity is prompting the clinical trials at Bochum to determine the effectiveness of the device in therapy.

"Our patients attain activity levels which improve their ability to navigate around their everyday life and their surroundings," said Thomas Schildhauer, medical director at University Hospital Bergmannsheil, which is aiding the trails. "Thus, they continue to train their movement routine every day."

A patient who had been permanently confined to a wheelchair, for example, will be able to walk short distances with the aid of a walking frame after a three-month training period, he said.

Further trails are being conducted, but Schildhauer said results so far have been "excellent." **ME**

JEAN THILMANY



HAL increases a user's effective strength; sensors detect neural signals from muscles to initiate movement.

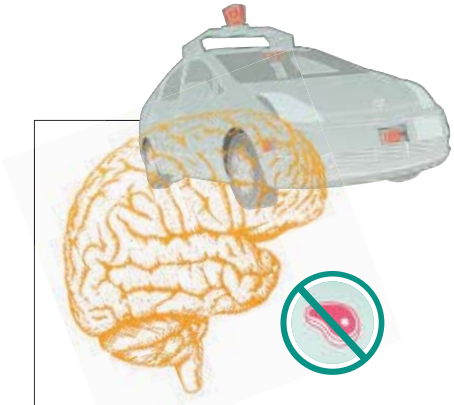
QUICK FACTS:

WHAT IT IS: The Hybrid Assisted Limb.

WHAT IT DOES: A powered frame gives mobility to wheelchair-bound patients.

DEVELOPER: Sankai Laboratory, Tsukuba University.

MARKETER: Cyberdyne Inc., Tsukuba, Japan.



If these things were possible to do, percentage of those surveyed who

WOULD		WOULD NOT
48%	Ride in a driverless car	50%
26%	Brain implant to improve memory or mental capacity	72%
20%	Eat meat grown in a lab	78%

SURVEY: LESS OPTIMISM, MORE CONCERN ABOUT TECHNOLOGY

AMERICANS ARE STILL OPTIMISTIC ABOUT THE LATEST engineering and scientific marvels, but are wary about many technologies that are close to reaching market, according to a study by the Pew Research Center and *Smithsonian* magazine.

Overall, twice as many Americans (59 percent) believed technological change will make people's lives mostly better than those who said it would make lives worse (30 percent).

Yet there are large discrepancies in the data. While age hardly matters, sex, income, and education do. For example, 67 percent of men are optimists, compared with only 51 percent of women.

Those earning $75,000 or more were three times more likely to say technological change will improve people's lives than not. Among those earning $30,000 or less, slightly more than half saw an upside, while 38 percent thought technology would make things worse.

Asked about technology, college graduates were three times more likely to be optimistic than pessimistic. For those with a high school diploma or less, 56 percent were optimists, and 35 percent pessimists.

Men with a college degree had an especially sunny outlook: 79 percent of this group believed that future technology will have a mostly positive impact, while only 14 percent expected a mostly negative impact.

Americans have mixed expectations about technologies that may emerge over the next 50 years. Eight out of 10 believe we will have lab-grown organs for transplant, and five out of 10 expect computers to create art as well as humans do. Americans view teleportation as more likely than weather control (39 percent vs. 19 percent). One out of three thought long-term space colonies likely.

Pew asked about four technologies closer to commercialization, and concerns emerged. For example, nearly two out of three Americans believe manipulating DNA to produce smarter, healthier, and more athletic children would be a change for the worse. Nearly the same number had negative views about using humanoid robots to care for the elderly and allowing drones to fly through most U.S. airspace.

The lines were more evenly drawn regarding wearable and implantable devices that stream information to users. Although 53 percent of respondents thought this would make things worse, 37 percent thought it would be a change for the better. While men were evenly split on the question, women went negative by a 59-29 percent margin.

The same caution showed up when Pew asked respondents if they wanted to try some new inventions. Only 48 percent said they would ride in a driverless car. There were more takers for brain implants to improve memory or mental capacity (26 percent) than there were for eating lab-grown meat (20 percent).

Finally, Pew asked people what futuristic invention they would like to own. Travel-related technologies scored highest overall, especially among people under 30. Time machines were also popular (who wouldn't want to go back and invest in Apple stock when it was $2 per share?), followed by health-related inventions. Personal robots were a distant fourth. Seniors older than 65 seemed less interested in future inventions, and 56 percent said either they couldn't name a technology they wanted or said flat-out they weren't interested in any. ■

Those surveyed who feel that the things listed below would be a change for the

	WORSE	BETTER
Most people fed info by devices or implants	53%	37%
Robot caregivers for elderly and infirm	65%	28%
U.S. airspace opened to personal drones	63%	22%
Parents can alter DNA of prospective children	66%	26%

SOURCE: *Pew Research Center 2014 survey*

A bioengineer combines baby pictures and ultrasound data to create a printable 3-D model of a fetus.

3-D DELIVERY

A CHILD IS AT HIS OR HER SMALLEST AND, ARGUABLY, MOST innocent while in the womb. What great irony, then, that nature has kept these prenatal wonders inaccessible to us, hidden from the bumps, knocks, and bacteria that life has to offer, yes, but also from our cuddling instincts.

A mom-and-pop company out of California is hoping to put an end to any infantile hands-on yearnings. With the help of a 3-D printer, that is. Parents hoping to wrap their arms around baby ASAP—and to keep a permanent copy of the tiny wonder for years to come—can now use 3-D ultrasound images to have their fetus printed in three dimensions.

Artistic license is used to increase the cuddle factor.

Katie Bessette and her husband, Gerard, were looking at baby pictures of their own children when the idea for 3D Babies popped into their heads. "Those memories are so poignant, and you forget so quickly how small they are," she says. "We started thinking of other ways to trigger those memories."

Since the world has plenty of flat old images to look at these days, why not something that would elicit stronger, tactile feelings?

"Why do we all have stuffed animals?" Katie asks, "Why do we have the need to touch?"

Strictly speaking, the images are not printed directly from 3-D ultrasound files—in part because those images are all too often less than cuddly—never mind that the babies are rarely cooperative when it comes to getting the perfect shot. "Those things are not clear," she says. "They're quite grainy, and maternal artifacts are everywhere. Sometimes the ultrasound pictures can be kind of scary. I try to put a little bit of the cute factor back into it."

continued on page 14»

WASHINGTON

$60 MILLION FOR TWO NEW ENERGY PROGRAMS

The Advanced Research Projects Agency-Energy has announced funding opportunities of as much as $60 million for two new programs—one to detect and measure methane emissions and the other to reduce the energy needed to heat and cool buildings.

The first program has the strange name "Methane Observation Networks with Innovative Technology to Obtain Reductions" so that it can be abbreviated "MONITOR." In the United States, methane emissions make up nearly 9 percent of all greenhouse gas emitted as result of human activity.

The MONITOR program aims to help the oil and gas sector reduce methane emissions and build a more sustainable energy future. The program will make up to $30 million available to help U.S. teams develop low-cost, highly sensitive technologies to measure methane emissions and provide a detection network to mitigate the release of the gas into the atmosphere.

The second program, Delivering Efficient Local Thermal Amenities, or DELTA, supports the development of innovative localized heating and cooling devices, to enhance personal comfort and save energy.

While most of today's temperature control systems are designed to heat and cool entire buildings, DELTA seeks to develop both installed and wearable devices that can regulate temperatures in close proximity to a building's occupants.

This localized thermal management will enable buildings to operate in wider temperature ranges while still ensuring occupant comfort, which would dramatically reduce the building's energy consumption and associated emissions. More information about funding opportunities is available online at arpa-e-foa.energy.gov. ■

continued from page 12 »

3-D DELIVERY

MAKING IT REALISTIC

To make the fetus realistic, but still conform more to our idea of cuddly, and not seem like a specimen on loan from the Mütter Museum, Katie became something of a sculptor. "I turn it into something parents would want to turn to year after year, instead of something so scientifically correct that you wouldn't remember it as how your child was when it was first born." To make the final composite file that will be sent to the printer, she draws on the ultrasound images, pictures of the parents, general baby pictures in various poses, and, if the unborn child to be printed is a child already extant, later photos of the offspring as well. "The images go from my files into my brain, into 3-D modeling software."

Katie Bessette, who received a Ph.D. in bioengineering, had some experience handling large image files of a biological nature. "It made it easier for me to transfer into this type of field. And the fact that we have our own two kids—you understand the love that's invested in the kid even before they're born." She went through 40-odd programs before settling on the one she thought was best for making babies.

"THE IMAGES GO FROM MY FILES INTO MY BRAIN, INTO 3-D MODELING SOFTWARE."

ENGINEERING CHALLENGES

Gerard Bessette, having had previous experience matching engineers with manufacturers, handles the business side of 3D Babies. He also waded through the world of 3-D printers to find the perfect delivery machine. He tried plastic deposition printers, but the resolution was too low. He tried a printer that used a ream of paper—great for things with straight lines, which doesn't include babies. He even tried a ceramic. "It's nice, but the details are not there," he says. "And if you drop it, that's it."

They eventually settled on using a Stratasys U-Print SE Plus, largely due to its support material. "It can be dissolved away with a wash buffer," Katie explains, "and it leaves you with only your designated material."

Even with the ideal printer, finding the right process took some time. "Our first couple of models were boxy, instead of round," Gerard says. "We had to figure out how to smooth it out. That was one of the engineering challenges we came across."

The biggest challenge, though, seems to be finding a market. Potential customers tend to find photos of the printed babies fascinating, but a bit on the creepy side.

"I realize that from just looking at the pictures, they have a point," Gerard says, "but when you show them the actual baby, it's one of the coolest things in the world." ME

MICHAEL ABRAMS, ASME.ORG

This inexpensive lens turns a smart phone into a field microscope.

MICROSCOPES

SEVERAL YEARS AGO, LIA MARSHALL and a group of fellow undergraduate students lugged ten to fifteen pound microscopes in their backpacks between rural communities in the Amazon. The microscopes figured into a public health experiment that showed people the tiny organisms living in their untreated water.

"Having visuals like microscopes or pictures is very helpful in demonstrating why doing things (like washing hands) that are otherwise inconvenient are important," said Marshall, who is now a master's student of environmental and forest sciences at the University of Washington in Seattle.

Now, thanks to a young inventor called Thomas Larson and his stick-on microscope lenses for mobile phones, students retracing Marshall's path through Amazon would have much lighter packs.

Larson began developing the lens as a mechanical engineering undergraduate at the University of Washington in 2012. In 2013, he funded the manufacture of Micro Phone Lenses through Kickstarter, earning nearly $92,000, which far surpassed his goal of $5,000.

That lens magnifies images by a factor of 15. It sells for $14.99 at his web site, www.microphonelens.com. He markets them as educational tools, a hobby for children, a field research aid, and, yes, even as a potential water quality tester

This year, he pulled off the same trick, funding the

"USING THE LENS FOR GLOBAL HEALTH WAS, AND STILL IS, MY PRIMARY INTEREST IN DEVELOPING THE TECH."

manufacture of a much more powerful lens that magnifies up to 150,000 percent. By the end of his Kickstarter campaign he had nearly $112,000, more than doubling his $50,000 goal. He's taking pre-orders for those lenses at his

GO MOBILE

website. They sell for $49.99.

When seeking funding, Larson didn't mention medical uses of the lenses because Kickstarter has a no-medical-device policy. But he spoke to Engineering for Change of their use in global health.

"Using the lens for global health was, and still is, my primary interest in developing the tech," Larson said. The lens is untested as a diagnostic tool and testing should be a first step before using it to diagnose disease. But if they hold up, the lenses could be used to diagnose for the blood flukes parasite or to help analyze blood smears, pap smears, or urinalysis. ME

ENGINEERINGFORCHANGE.ORG

Thomas Larson has funded the development of his mobile phone lenses through Kickstarter.

THE PROGRESSION OF PROGRESS

Society's challenges are not insurmountable. But we have to get energy, water, and food production right before we can tackle anything else.

Today's on-line media is overrun with numbered lists: The 11 foods you should never feed your dog, the 7 insane things Walt Disney proposed for Disneyland; the 5 top Android apps for engineers. Most of those lists are scarcely worth the effort to click through. But in May 2003, Nobel laureate Rick Smalley of Rice University presented his own numbered list during a lecture at the Energy & NanoTechnology Conference in Houston. His "Top Ten Problems of Humanity for the Next 50 Years" is a list for the ages.

Smalley presented his list of problems in order of importance to society, beginning with energy, and moving through water, food, environment, poverty, terrorism and war, disease, education, democracy, and finally population.

The order of those problems was the result of careful consideration, and more than a decade later—after such foundation-shattering events as the shale gas boom, Hurricanes Katrina and Sandy, and popular revolts around the world—the logic of this sequence still rings true.

Notably for a lecture given months after the start of the Iraq War, energy and water are at the top of the list, ahead of war, democracy, or even food and shelter. That is partly because energy and water enable everything else we care about. But also, from Smalley's perspective, getting energy and water right gives us the ability to solve subsequent problems in a cascading fashion. That is, solving one of those grand challenges usually leads to a solution to the next lower challenge in the list.

Education, for example, was ahead of democracy because it is difficult to have a fully functioning democracy without an educated populace. Terrorism and war are often triggered by disputes over resource constraints and intractable poverty; solving those challenges won't necessarily eliminate war, but it removes one of its forcing functions.

But energy is the great enabler for all else that follows. Abundant sources of clean, reliable, affordable energy become an enabling resource for developing an abundance of clean water, via either the construction of large freshwater-moving projects, deeper wells, or advanced desalination plants. Having an abundance of clean water enables, in turn, advances in food production. And, solving the world's energy, water, and food problems opens up the door to tackling our other societal challenges, from environmental degradation through overpopulation.

TAKEN ON IN THE RIGHT ORDER, SOLVING ONE GRAND CHALLENGE USUALLY LEADS TO A SOLUTION TO THE NEXT ON THE LIST.

This is the energy-water-food nexus, and it's time the nation and the world focus on its importance.

Mechanical engineers have an important role to play for each of these grand challenges, but especially the ones at the top of Smalley's list.

We can work to accelerate the pace of innovation to make it possible to—optimistically—anticipate an era when the energy problem is mostly solved. Indeed, with solar prices plummeting and distributed generation and energy efficiency on the cusp of taking off, a radically new energy era is waiting just below the horizon.

Getting to that point doesn't mean engineers have solved humanity's problems. It means that water replaces energy as the next roadblock to a fully liberated, healthy, peaceful civilization. So engineers will be called on again: to design better pumps to move water around, better membranes to treat the water, and better sensing technologies to avoid leaks and manage its use with embedded information.

And once we've solved water, then we can move on to taking on food.

Following Smalley's list makes it easy to sketch out a plan. But we're missing key ingredients to turning the sketch into an operational blueprint. We need a sustained, stable, program of R&D investments focused on these challenges, and in particular the interconnections of these challenges. And we won't get workable solutions without a modern academic setting that celebrates multidisciplinary work and encourages students to tackle our largest systemic problems.

If we get that right—and use Smalley's list as our roadmap—then engineers just might solve the world's problems. ME

MICHAEL E. WEBBER is the Josey Centennial Fellow in Energy Resources and associate professor of mechanical engineering at the University of Texas at Austin.

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THE ENERGY COSTS OF SWIMMING

MOST COMIC BOOK READERS HAVE SPENT IDLE hours pondering who would win in a fight, Superman or Batman. But as for the question of which animal swims more efficiently, a tuna or a whale, that's something that only a mechanical engineer would think to ask.

Indeed, Neelesh Patankar and his colleagues in the mechanical engineering department at Northwestern University in Evanston, Ill., looked at the energy expended by swimming animals of various sizes, and contrary to previous studies, found that big whales and medium-size tuna are comparably efficient.

Up to now, it's been thought that swimming animals expend energy to accomplish two things: to undulate their bodies to create propulsion and to overcome the drag of moving through the water.

By a new metric, fin whales are no more efficient than other swimming animals.

LONG LIFE, NO FIRE RISK

A NEW SOLID-STATE BATTERY DESIGN COULD MAKE LAPTOP computers and electric vehicles much safer.

The long life of lithium ion batteries makes them the rechargeable battery of choice for everything from implantable medical devices to electric vehicles. But lithium ion batteries also have a reputation for occasionally catching fire when damaged. The flammability risk is due to the composition of the battery—lithium salts dissolved in organic solvents. That risk would be avoided if the cells were completely solid.

Now a team of researchers at Tohoku University in Sendai, Japan, has created a new type of lithium ion conductor for batteries that one day could be the basis for a whole new generation of solid-state batteries. It uses rock salt lithium borohydride ($LiBH_4$), a well-known agent in organic chemistry laboratories.

THE FLAMMABILITY RISK OF LITHIUM ION BATTERIES IS DUE TO THEIR COMPOSITION —LITHIUM SALTS DISSOLVED IN ORGANIC SOLVENTS.

The substance has been used for batteries before, but up to now has only worked at high temperatures or pressures, said Hitoshi Takamura, who led the research at Tohoku University, where he's an associate professor in the department of materials science.

Instead of using molten salt, the researchers loaded a lattice made of potassium molecules with $LiBH_4$. This allowed them to stabilize the high-pressure form of $LiBH_4$ and make a solid solution that is stable at room temperature and at usable temperatures and pressures.

The team discovered that the lattices acted like lithium conductors although they were made of potassium. This is the reverse of the usual technique in which a small amount of stabilizing element would be added to an ionic conductor abundant in lithium.

"In other words, $LiBH_4$ is a sort of parasite but not a host material," Takamura said. He and his colleagues call this mechanism "parasitic conduction" and suggest it could be broadly applied in the search for new batteries—anywhere that small amounts of lithium ions could be loaded into an oxide, sulfide, halide, or nitride host material.

"This work suggests the potential of this mechanism in the ongoing search for the perfect material for use in solid state batteries," Takamura added. ■

FOR THE FISH AND THE WHALE

Since bigger animals have more muscle mass per surface area, it was thought that they would be subject to less drag, pound-per-pound, than smaller animals.

Of course, the differences in size of swimming animals—a gray whale is some 200,000 times larger than a sardine—made comparisons less like apples-to-apples and more like watermelons-to-peas.

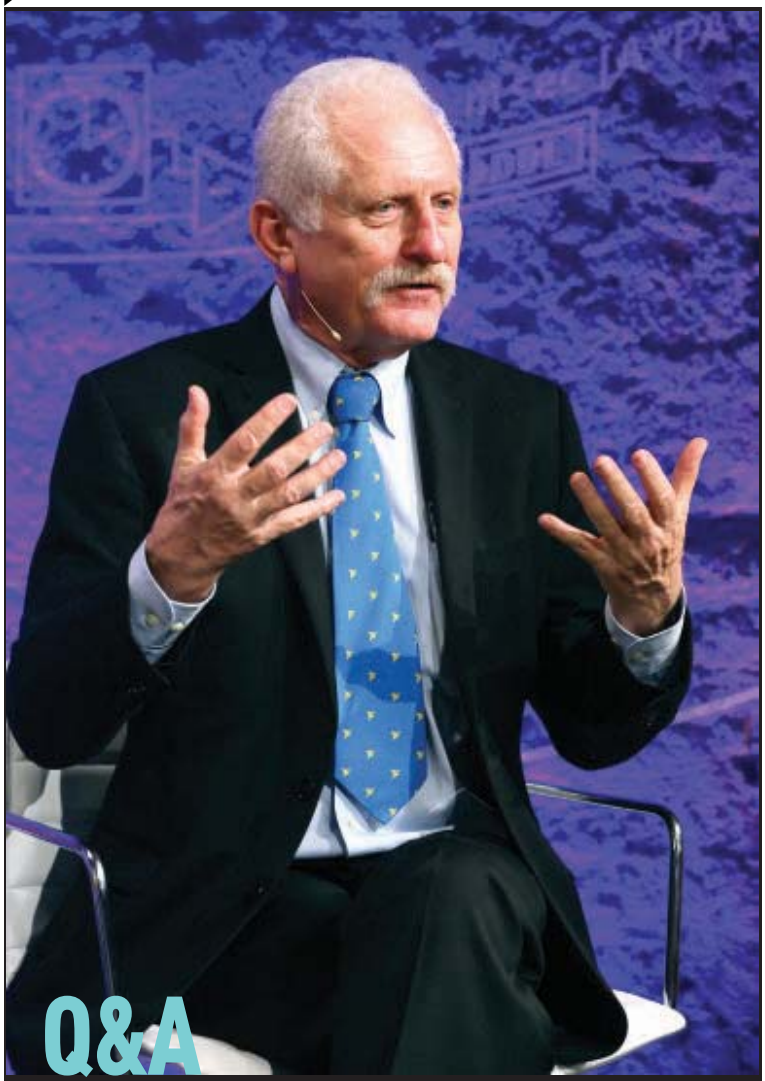
Patankar and his colleagues wanted to create a metric for understanding the energy cost of swimming for animals of all sizes, so they developed what they call the energy-consumption coefficient that acts like a measure of fuel consumption. The energy-consumption coefficient takes the basic measure of energy spent per distance traveled and adjusts it based on such factors as the wavelength, amplitude, and frequency of the undulations in the animal's body as it swims and the area of the animal's body in the direction of the undulations.

After calculating that energy consumption coefficient for thousands of animals, the researchers found that there was a sharp dividing line between small swimming animals—those with a mass of less than a kilogram—and larger ones. But in each case the energy cost of moving through the water seemed to scale proportionally to the mass of the animal raised to the power of 2/3.

That means that by this metric, most fish and whales swam about as efficiently as every other fish and whale.

Though Patankar's team studied animals, including the efficiency of flying insects, bats, and birds, the metric can be applied to machines as well. They hope that their energy consumption coefficient will someday be applied as commonly as is the drag coefficient, and with a similar effect on improving design. ME

JEFFREY WINTERS



Q&A JAMES TRUCHARD

JAMES TRUCHARD WAS AN ENGINEER WITHOUT any business background when he, Jeff Kodosky, and Bill Nowlin founded National Instruments. The three had been part of a team collecting and analyzing data for the U.S. Navy using early computer technology. Seeking a technology for data collection, in 1976 they began working in Truchard's garage, where they designed an interface board that would later become National Instruments' LabView graphical programming platform. Today, Truchard is a member of the National Academy of Engineering and president and CEO of NI, a company of 7,114 employees and more than $1 billion in revenues.

ME: How did you come to found National Instruments?

J.T: In 1976 I was working with Jeff Kodosky and Bill Nowlin at the University of Texas at Austin Applied Research Laboratories, as part of a project conducting research for the U.S. Navy. Our frustration with inefficient data collection methods is what led to our use of minicomputers to build test and measurement systems. In hindsight, this redefined how instrumentation had been built, and it went on to form our long-term vision for virtual instrumentation.

ME: What do you like about your work?

J.T: Collaborating with engineers on new ideas and then seeing customer success with them.

ME: What do you do in your spare time?

J.T: I've spent the last 10 or so years developing the landscape around my house and I documented the process throughout by taking photos. They'll be published in the book, *Memories from a Hill Country Garden: Flowers, Stones, and Critters*. It'll be ready for distribution this year, and I plan to donate books to organizations for fundraising. I also enjoy wine and have a cellar at home. My brother has a vineyard, Truchard Vineyards.

ME: Any advice for engineers that you've learned on the job at NI?

J.T: To harness the rapid pace of change and increasing complexity of engineering, you must think differently about how to solve a system problem. Our company philosophy is to take a long-term approach to decision making. The long-term vision is known as the 100-year plan.

ME: Anything you wish you'd done differently, as a founder?

J.T: I've learned all investments should be aligned with our platform because the platform depends on how well the components are aligned. Anytime we deviated from this, we did not achieve desired success.

ME: What's your favorite book?

J.T: *Built to Last: Successful Habits of Visionary Companies* by Jim Collins and Jerry I. Porras (Harper Business Essentials, 1994) and *Thriving on Chaos: Handbook of Management Revolution* by Tom Peters (Knopf, 1987) as they're both relevant to our business strategy.

ME: What are you reading right now?

J.T: Nothing! I'm very busy wrapping up the publication of my own book, fixing up my house. ME

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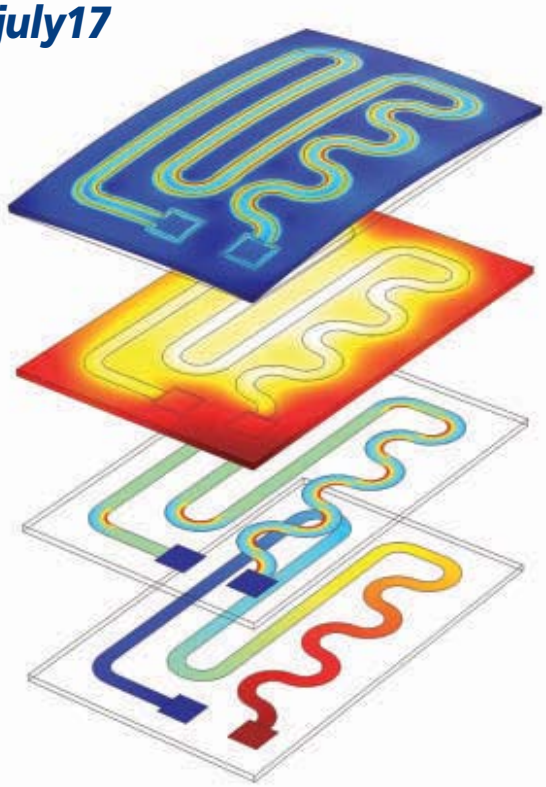

Multiphysics simulation of a heating circuit including DC-induced Joule heating, heat transfer, and structural mechanics of the thin resistive layer covering a solid glass plate.

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Scooters with two-stroke engines are a major source of air pollution.

DIRTY SCOOTERS

SOME PEOPLE LOVE THE FEEL OF FREEDOM as they zip around town on a scooter. However, the blue cloud some leave in their wakes is worse than the pollution from a diesel truck.

They are a niche vehicle in North America, but scooters are a main mode of transportation in cities worldwide. Scooters with two-stroke engines, which are cheaper and easier to maintain than their four-stroke cousins, are less common on the roads.

But what two-stroke scooters lack in numbers, they make up for in noxious emissions. A pan-European team of researchers, led by atmospheric chemists at the Paul Scherrer Institute in Villigen, Switzerland, has found that an idling two-stroke scooter produces certain types of pollution at rates up to a thousand times greater than a large diesel truck or other vehicles.

In terms of soot, organic aerosols, and aromatic hydrocarbons such as benzene produced by vehicles, the researchers wrote, "Our data suggest that [two-stroke] scooters are the largest source in many cities."

Unlike four-stroke engines, two-stroke engines burn a mixture of gasoline and lubricating oil. During the engine cycle some unburned fuel and fresh air pass directly through, which contributes to the emissions of volatile organics.

Emissions of benzene, a cancer-causing substance, were particularly worrisome, the authors wrote. Idling scooters were producing benzene at a rate of 146 parts per million; U.S. worker safety regulations require respirators when levels are greater than 1 ppm. Waiting behind a scooter at a stoplight, the researchers said, could be a health hazard.

The authors estimate that, in parts of Asia where scooters are more popular and regulations are often more lax, two-stroke scooters could be responsible for between 60 and 96 percent of certain kinds roadside pollution.

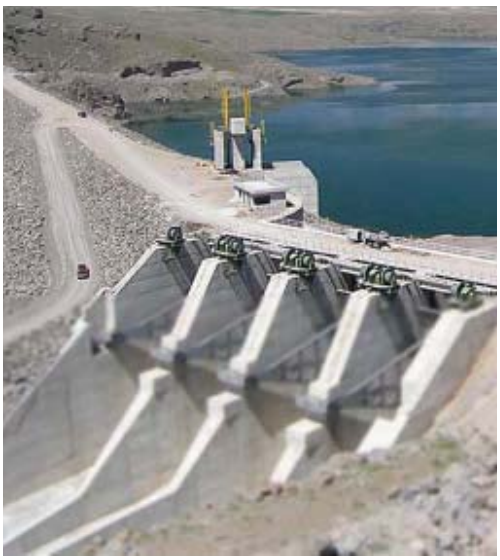
The paper, "Two-stroke scooters are a dominant source of air pollution in many cities," was published in the May 13 edition of *Nature Communications*. ME

A CHANCE TO DOUBLE U.S. HYDRO POWER

THE DEPARTMENT OF ENERGY and its Oak Ridge National Laboratory issued a report which estimates that the U.S. has the untapped water power to double its current hydroelectric capacity.

According to the report, the available power of more than three million rivers and streams in the country could generate a total of 65 gigawatts of electricity, equivalent to the current U.S. hydropower capacity.

Hydropower makes up 7 percent of total U.S. electric generating capacity and continues to be the United States' largest source of renewable electricity, avoiding over 200 million metric tons of carbon emissions each year. Hydropower also provides reliable baseload power day and night, providing greater flexibility and diversity to the electric grid and allowing utilities to integrate



"America is on the cusp of becoming the world's largest energy producer. Our vast reserves also give us the enormous potential for growth. However, it is not enough to be a world leader in producing energy—we must also remain a world leader in safely transporting that energy."

—*Cynthia L. Quarterman, administrator of the Pipeline and Hazardous Materials Safety Administration, at a hearing of the House Committee on Transportation and Infrastructure.*

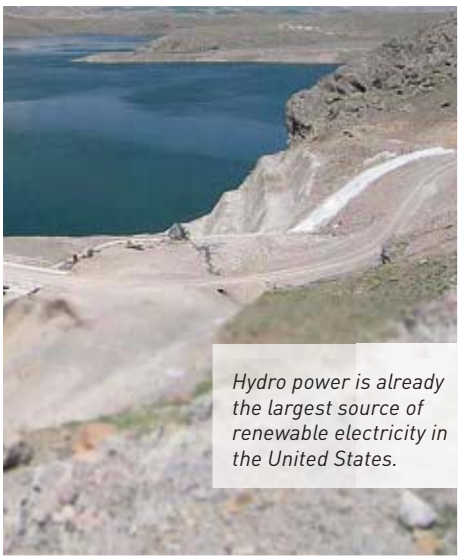
other renewable sources such as wind and solar power.

The report, called "New Stream-reach Development Assessment," takes advantage of recent advancements in geospatial data and represents the most detailed evaluation to date of U.S. hydropower potential at undeveloped sites. The greatest hydropower potential was found in mostly western U.S. states.

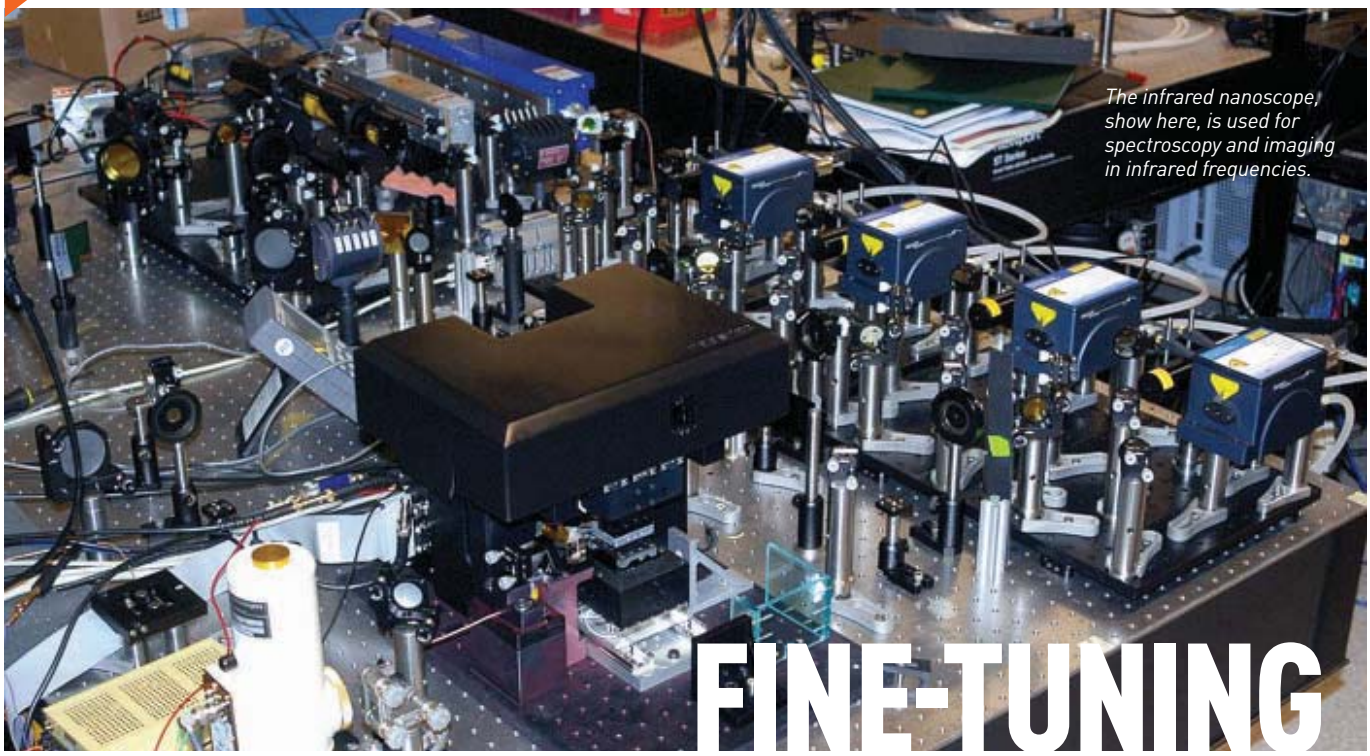
THE AVAILABLE POWER OF RIVERS AND STREAMS COULD GENERATE A TOTAL OF 65 GW OF ELECTRICITY.

The hydropower resource assessment also analyzed technical, socioeconomic, and environmental characteristics that will help energy developers, policymakers, and local communities identify the most promising locations for sustainable hydropower facilities. The assessment includes stream- and river-specific information on local wildlife habitats, protected lands, water use and quality, and fishing access areas.

Additional information on the new assessment may be found at nhaap.ornl.gov/nsd. ■



Hydro power is already the largest source of renewable electricity in the United States.



The infrared nanoscope, show here, is used for spectroscopy and imaging in infrared frequencies.

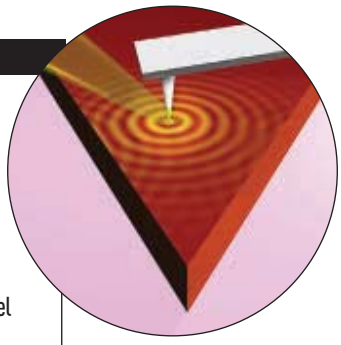
FINE-TUNING MATERIALS

SOLID LIGHT WAVES

THE LAB Basov Infrared Laboratory, University of California, San Diego; Dimitri Basov, principal investigator.

THE OBJECTIVE The use of infrared spectroscopy to investigate novel physics of electronic and magnetic materials.

THE DEVELOPMENT Wave generation and size adjustment within a crystal.



A beam of infrared light, illustrated above, propagates across layers of a hexagonal boron nitride crystal to make waves in the material.

Metamaterials have garnered attention in recent years. Because their properties come from their physical structures—minuscule components arranged in a specific pattern—rather than from their chemical makeup, metamaterials can be engineered to act in ways impossible for natural materials. This month, we look at two labs working with metamaterials and how their research could lead to future applications in quantum computing and nanoscale electronics.

Researchers at the University of California, San Diego have found that a beam of light can make waves in crystals and those waves can be tuned—a phenomenon that might lead to the transmission of information in computer chips, better management of heat flow in nanoscale devices, or the creation of higher resolution images than now possible, said UCSD physicist Dimitri Basov.

Basov's team fired a beam of infrared light at an atomic force microscope as it scanned across a 2-D material, hexagonal boron nitride. The microscope uses a needle at the end of an arm to probe atomic and molecular surfaces.

The microscope transferred momentum from the light to the crystal, causing the light to generate waves in the boron nitride. The waves, called phonon polaritons, had wavelengths as short as those of ultraviolet light, at about 300 to 400 nanometers. The waves generated can be maintained long enough to be usable for practical applications, Basov said.

"A wave on the surface of water is the closest analogy," he said. "You throw a stone and you launch concentric waves that move outward. This is similar. Atoms are moving. The triggering event is illumination with light."

The atoms of boron nitride form layers that are stacked on top of one another and held together by forces between molecules. By adjusting the wavelength of the light and varying the number of layers of the boron nitride, the researchers were able to adjust the shape and size of the polaritons, or tune them to specific frequencies or amplitudes.

Controlling the wave size means the crystal could be used to transmit information. Also, control of waves could be important to building nanometer-scale circuits.

"You can direct information where you want it at the nanoscale," Basov said.

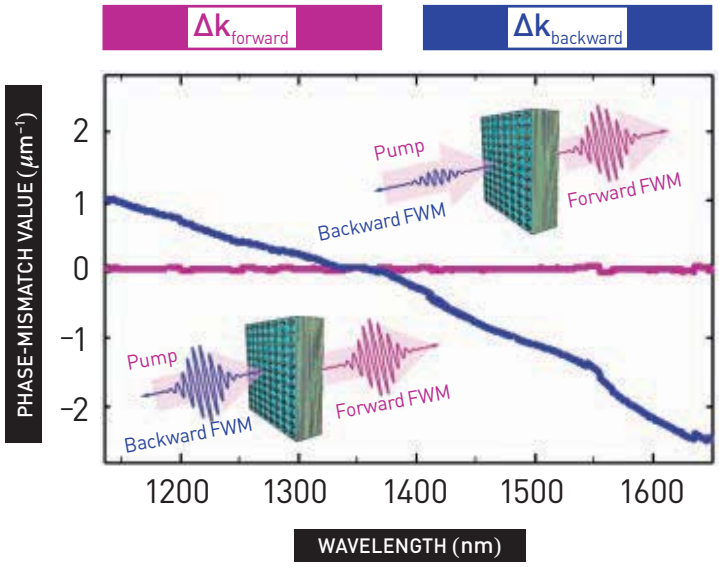
LIGHT FOR QUANTUM NETWORKS

THE LAB Lawrence Berkeley National Laboratory, materials sciences division; Berkeley, Calif.; Paul Alivisatos, laboratory director.

THE OBJECTIVE Development of experimental techniques to understand new materials and phenomena at the scale of time and length.

THE DEVELOPMENT Moving light through a metamaterial without destructive interference.

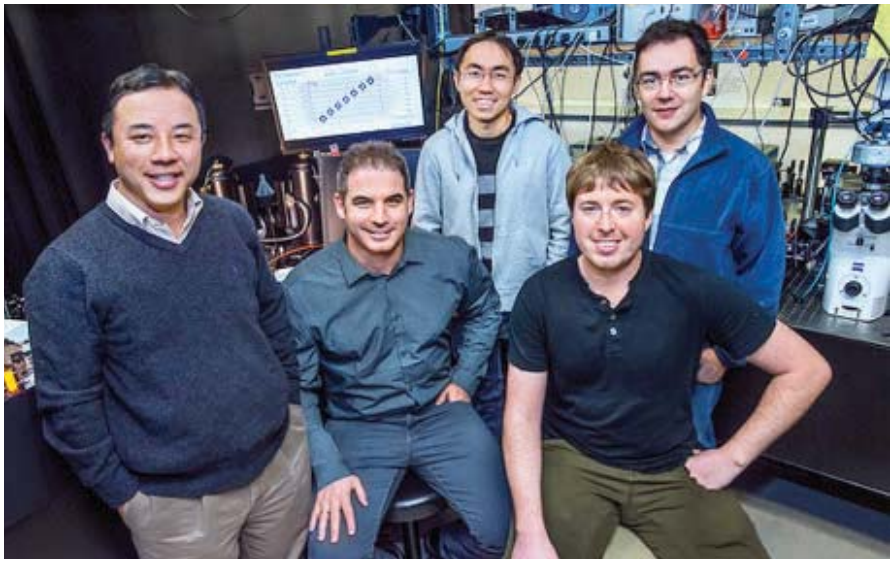
The graphic shows four-wave mixing in a positive-index, upper, and zero-index, lower, metamaterial. FWM is about the same in both directions for the zero-index metamaterial.



The next frontier in computing involves quantum processors, which are expected to be many times faster and more powerful than today's supercomputers. Such computers could manipulate bits of quantumly entangled light rather than electrical signals to process information.

One problem with using photons to carry information is they hardly interact with each other. While adding nonlinearity to the linear optical network may help realize quantum computation, implementing nonlinear optical effects isn't easy.

But in a study led by Xiang Zhang, a faculty scientist in the materials sciences division at Lawrence Berkeley National Laboratory, a research team used an optical metamaterial with a refractive index of zero to generate "phase mismatch–free nonlinear light."



The LBNL team, from left: Xiang Zhang, Haim Suchowski, Zi Jing Wong, Kevin O'Brien, and Alessandro Salandrino. They created a metamaterial that holds promise for quantum computing networks.

The phase mismatch-free quality holds promise for optical quantum computing and networking.

Nonlinear optical processes are a challenge to achieve and maintain because of the phase-mismatch problem, Zhang said. The interaction of intense laser light with a nonlinear material can generate light of a different color. But if the phases of the new and old photons aren't exactly aligned, the waves can produce destructive interference.

In a zero-index metamaterial, the phases of propagating light waves are mismatch-free in both directions, Zhang said, which eliminates the problem of destructive interference.

Researchers had previously shown that a metamaterial could be engineered to yield an index of zero. A beam of light shining through this zero-index metamaterial was unaffected, as if it had passed through a vacuum. Building on this, the Berkeley researchers engineered a zero-index metamaterial that generates light, Zhang said.

"In our demonstration, we observed equal amounts of nonlinearly generated waves in both forward and backward directions," he said. "The removal of phase matching in nonlinear optical metamaterials may lead to the generation of entangled photons for quantum networking."

The metamaterial created in the lab features a fishnet structure—a stack of metal-dielectric multilayers with perforated holes. The fishnet consists of 20 alternating layers of gold films 30 nanometers thick and magnesium fluoride films 50 nanometers thick on a 50-nanometer thick silicon nitride membrane. ME

WHEN BIGGER ISN'T BETTER

ECONOMIES OF SCALE AND NETWORK EFFECTS TEND TO PUSH systems to being as large as possible. A railroad that services New England isn't as useful as one that runs from coast to coast.

The operators of the North American electrical grid have been growing in recent years due to a series of mergers of more local organizations and interconnections between those operators. Such large-scale grids allow for more generating stations to contribute electricity, and that diversity should enable lower costs and greater reliability. The Eastern Interconnection, for instance, now stretches from northern Manitoba to the Florida Keys.

But the benefits of scale may be limited. Researchers from the University of Alaska and Iowa State University have modeled one part of the North American grid and have found that beyond a certain size, growing the grid tends to increase the risk of blackouts.

The researchers created a network model that had a node for each generating station, substation, and step-down transformer on the grid. They then examined how a subset of the model reacted to local outages, especially when it was operating at full capacity as the electrical system often does in summer to accommodate peak air conditioning demand.

According to University of Alaska physicist David Newman, the optimal size for such a grid was between 500 and 700 nodes. Beyond that point, the benefit of providing more back-up power was outweighed by the risk of local outages becoming widespread blackouts.

The actual western grid has the equivalent of 16,000 nodes.

According to the paper, which Newman and his colleagues published in the journal *Chaos*, a better solution than a continent-spanning grid is a system of smaller regional grids that are more weakly coupled to one another. This would limit the spread of a network failure, and make it easier to fix since neighboring areas could send in repair crews to help out rather than have to scramble to fix their own blackouts. ■

LOOKING BACK

Desulfurization of flue gas, a key to controlling acid rain, was an emerging practice when this article was published in August 1984.

COMMERCIAL UTILITY FLUE GAS DESULFURIZATION SYSTEMS

BY J. DAVID MOBLEY, INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY, U.S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, N.C.; JAMES C. DICKERMAN, RADIAN CORP., AUSTIN, TEXAS.

In 1984 the New Source for Performance Standards rules were having an effect on the power industry. The technology of choice for removing sulfur from the exhaust of coal-fired power plants was wet limestone.

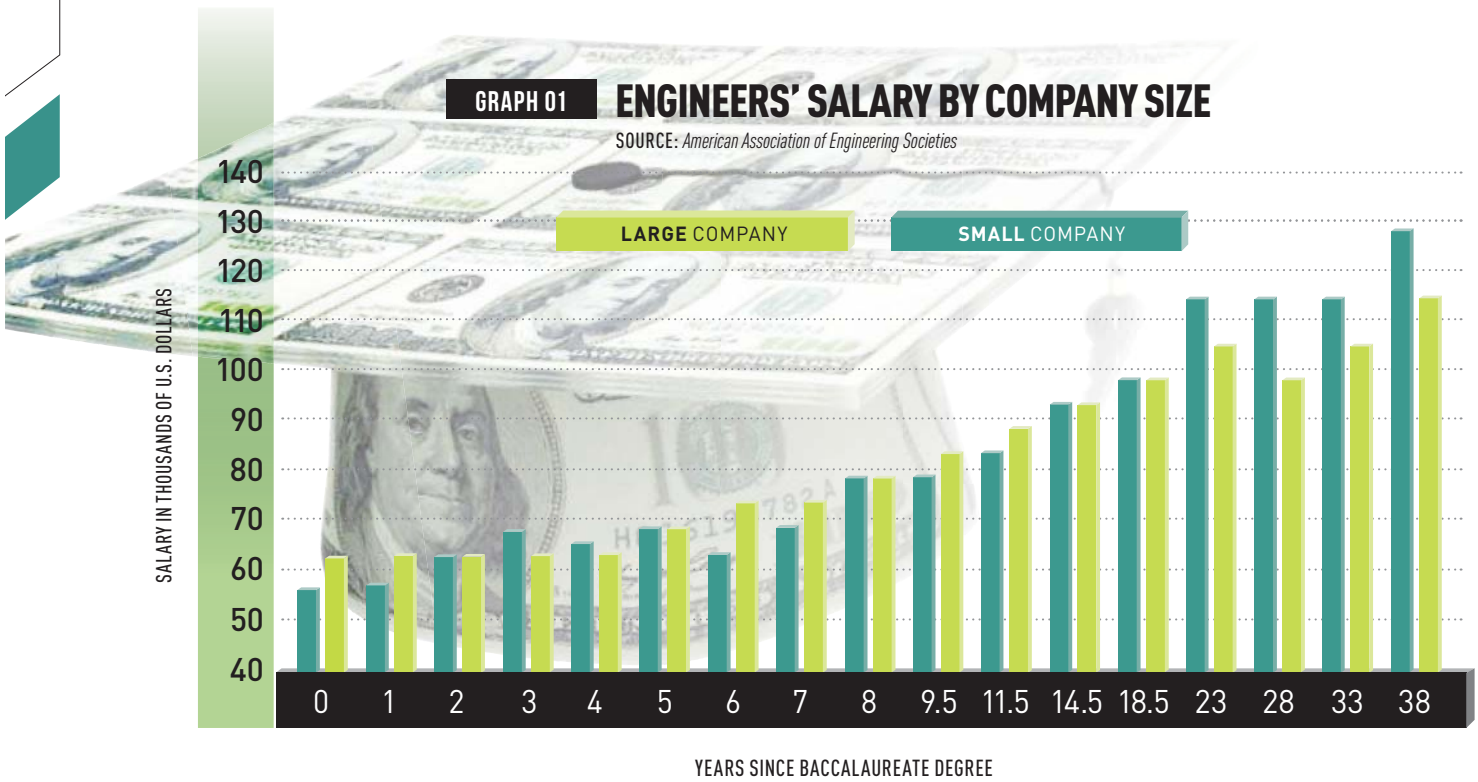
The 1979 NSPS (New Source for Performance Standards) for utility boilers requires FGD systems on all new coal-fired boilers. Since initial promulgation on Sept. 18, 1978, 73 FGD systems representing over 35,000 MW of capacity have been constructed, contracted, or planned by the utility industry. In the previous seven years, 48,000 MW (117 units) had been built with FGD systems. Since the promulgation of the 1979 NSPS, the wet limestone FGD process has been selected for nearly two-thirds of the future plants. The predominance of this process is due to its technical flexibility and favorable economics. Improvements in reliability and efficiency (due to the use of spray towers, forced oxidation, and SO_2 removal enhancement additives) enable the limestone process to be used in many applications.

The use of spray drying to control SO_2 and particulates from lower sulfur coal is the only other technology to be widely favored in the industry. Many commercial spray drying systems will soon be on line, demonstrating this technology. The other throwaway systems (lime, dual alkali, alkaline ash, sodium carbonate) will probably be used infrequently at new plants. Higher reagent costs are the primary reason for the lack of new orders for these systems. The regenerable systems, due to their higher costs, will probably be used only in specialized applications; e.g. land-restricted sites and those with favorable SO_2 regeneration opportunities. ME

A boycott of the 1984 Summer Olympics in L.A. led to a run on free Big Macs.

GONE FOR THE GOLD

While Mobley and Dickerman were responding to environmental policy, the world of sports was being rocked by international relations. The Summer Olympics, which began in Los Angeles on July 28, 1984, and was intended to be a celebration of human cooperation, was disrupted by a boycott of the games by 16 nations. This action followed a U.S.-led boycott of the Moscow Olympics just four years earlier. The 1984 Games went on as scheduled, but the absence of competitors from such athletic powerhouses as the Soviet Union, East Germany, and Cuba affected the results. Specifically, the United States won 83 gold medals, including ones in events such as wrestling and synchronized swimming that they had not been expected to do so well in. As a result, the McDonald's restaurant chain, which had a promotion tied to the U.S. medal count, ran short of Big Macs in many of its outlets.



GRAPH 1 Engineers in companies with fewer than 500 employees tend to make more than those at companies with more than 5,000 employees later in their careers. Engineers at small companies begin to benefit from higher salaries about 21 years after earning an undergraduate degree.

BY THE NUMBERS: PATTERNS

It's no surprise that engineering supervisors later in their careers make more than non-supervisors or those fresh out of college. But did you know that master's degrees take about 20 years to pay off?

Engineers see their salaries start to grow about five years after earning their bachelor's degree and then see their salaries rise at modest regular intervals, according to the most recent *Engineering Salary Survey* by the Engineering Workforce Commission of the American Association of Engineering Societies.

The survey also found that, later in their careers, engineers at smaller companies earn more than those at larger companies and that the salary gap between supervisors and those without supervisory roles widens.

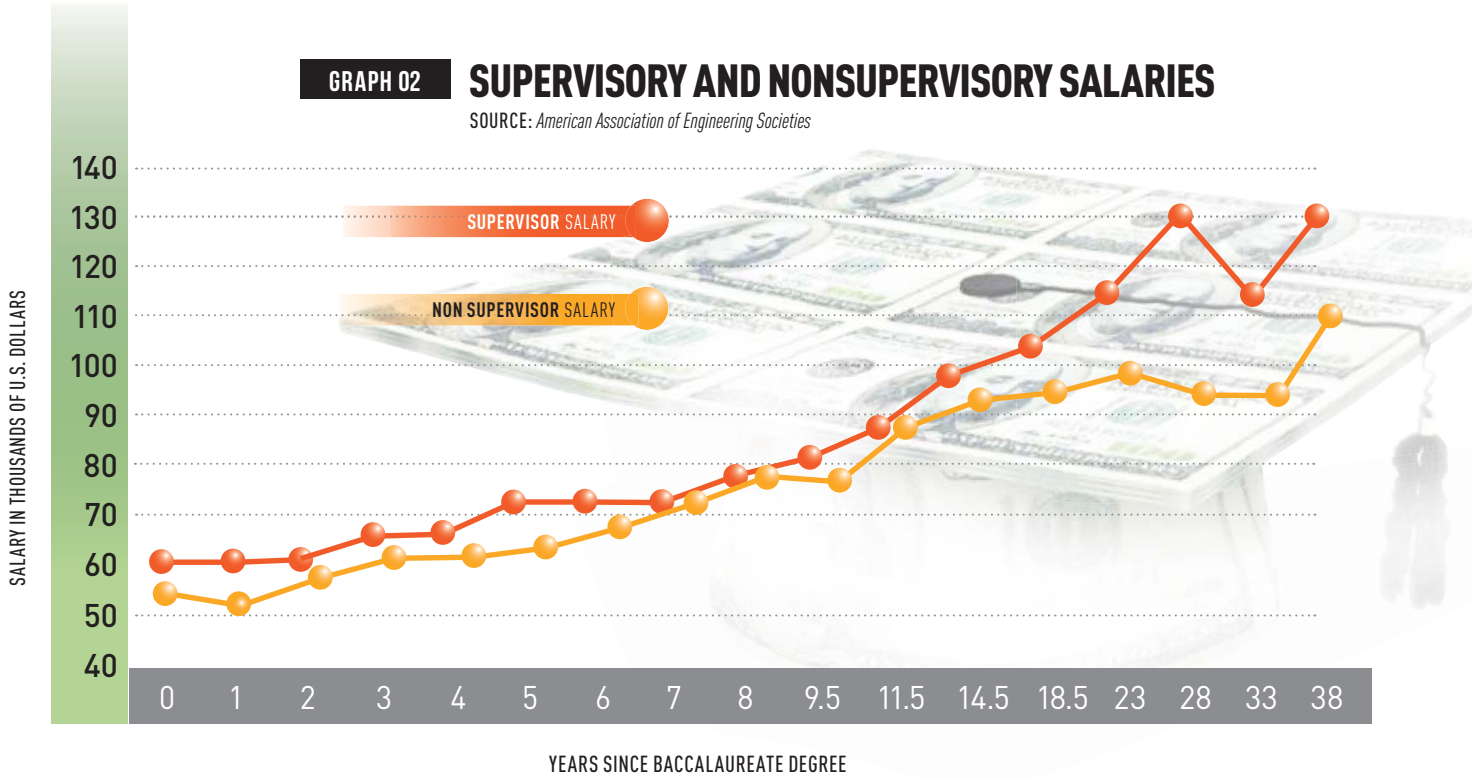
For this, its 46th engineering workforce survey, the commission collected data from employers on engineers' base salaries by levels of experience, supervisory responsibility, and academic preparation. The survey represents the data for 6,712 engineers in industry and government, according to the commission.

The survey looked at engineers through 38 years of employment following their earning a bachelor's degree.

"The median engineering salary remains flat at $62,500 until their fifth year post undergraduate schooling. At year five, the median engineering salary grows by about 8 percent to $67,000 and continues to expand by an average 5 percent cumulatively per year thereafter," according to the *Engineering Salary Survey*.

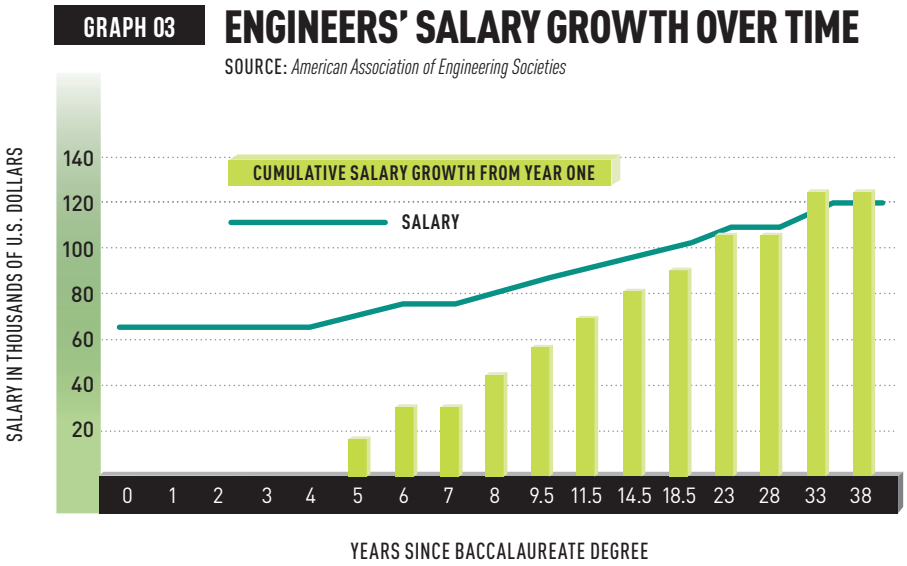
Engineers saw salaries grow by 15 percent over starting pay by their sixth year after graduating. Thirty-three years after earning a bachelor's degree, engineers surveyed were earning 63 percent above their starting salary, at slightly more than $120,000, a number that held steady in the following five years of employment.

Later in their careers, engineers who work at companies with fewer than 500 employees tend to make more money than those at companies with more than 5,000 employees. Engineers at the small companies begin to benefit from higher salaries about 21 years



GRAPH 2 The salary gap between engineers with supervisory responsibilities and those without remains stable for the first 16 years of experience. After year 16, however, the gap between supervisors and nonsupervisors grows from an average of about 8 percent to around 19 percent.

OF SALARY GROWTH



GRAPH 3 The median engineer salary remains flat at $62,500 for the first five years after college graduation. After that, the median salary jumps by about 8 percent to $67,5000, and grows by about 5 percent every subsequent year.

after earning their bachelor's degree.

The survey found that the salary gap between those with and without supervisory responsibilities widens considerably after about 16 years' experience. After year 16 the gap between supervisors and non-supervisors grows from about 8 percent to an average 19 percent. By year 38, supervisors were compensated at about $130,000 annually whereas those without a supervisory role drew salaries of about $110,000.

In another key finding, engineers with master's degrees make about 2 percent more on average than those whose highest degree is a bachelor's. The survey found that the salary advantage of holding a master's degree is not largely realized until about 18 to 20 years after undergraduate education.

AAES sells the report, which is available online at ewc-online.org/publications/index.asp.

The American Society of Mechanical Engineers is an AAES member. **ME**

JEAN THILMANY

✦ Later this year the first of as many as 12 sleek service vessels will throttle up and churn from Port Fourchon on the Louisiana coast, speeding to offshore rigs miles out in the Gulf of Mexico. The scene plays itself out daily in the Gulf oil fields, but this sailing will be different. The ship will be powered by liquefied natural gas, the vanguard of an effort by service providers to exploit historically low prices and meet stricter marine emissions standards.

Natural gas may be on its way to become the darling of alternative fuels. On land, truck manufacturers are looking at LNG's greater carrying capacity to fuel fleets of heavy duty trucks. Already, service companies such as United Parcel Service are moving to take advantage of lower costs and emissions, powering a new fleet of trucks with natural gas instead of gasoline or diesel. Construction and other off-road equipment is being fitted for natural gas and railroads are working with two locomotive manufacturers to bring LNG-fueled engines to the rails.

All of this activity flows back to a bonanza being extracted from previously impenetrable shale formations scattered throughout the U.S. Producers are now pulling volumes of natural gas and oil once thought beyond reach.

As producers fine-tune drilling techniques into unconventional formations to extract more gas faster and cheaper, the burgeoning market is trying to find outlets for it. Delivery companies are converting fleets of trucks from diesel to gas, and engine manufacturers are producing a wider range of natural-gas and dual-fuel engines. After Russia's annexation of Crimea, lawmakers have noticed too, proposing the U.S. start exporting liquefied natural gas to Europe, which is heavily dependent on Russian supplies.

Until now, the U.S. has never been a player in

A tanker is docked at the Golden Pass LNG terminal in Sabine Pass, Tex. The terminal has approval to export liquefied natural gas overseas.

spinning liquid gold

Advanced drilling and production techniques have given the United States more natural gas than its markets can handle. Converting that bounty into liquefied natural gas promises to transform the U.S. gas industry into a global energy power.

BY JOHN KOSOWATZ

exporting natural gas. But the "shale gale" may change that, having pushed the U.S. ahead of Russia as the world's top producer of natural gas. Many in Western Europe may prefer to buy their natural gas from the U.S. "Europe and others will see it's good to have more sources from political friends, from where you import your energy," said Torstein Hole, Statoil's vice president of onshore services in North America. The Norwegian energy giant has stakes in U.S. shale formations producing natural gas and oil.

✦ **Much of the jump** in production tracks back to the Marcellus shale formation running under Appalachia. Within five years, the formation went from near zero gas output to supplying about 20 percent of the total volume produced in the U.S., according to the U.S. Energy Information Administration.

As a result, natural gas in the U.S. costs a quarter to a third of the energy equivalent of oil. In Europe, imported LNG costs $8 to $12 per MMBtu and in Japan the cost hovers around $17,

A driver wears insulated gloves and a face shield as he transfers LNG from a terminal to a tanker truck.

roughly the same as oil. With oil still pricing at $103 per barrel, power, industrial, and manufacturing operations are looking to convert to gas.

"This is one of the most exciting times in energy in the U.S.," said Roger K. Rodiek, business development manager for U.S. power with global engineering firm Parsons Brinckerhoff. "I've been in the business since 1991 and I've never seen anything like it."

Domestic distribution of natural gas is generally conducted through pipelines, which transport compressed and pressurized gas. To prepare it for the international energy market, that gas must be converted to LNG in expensive and energy-intensive liquefaction trains that chill the gas to -260 °F. Gas turbines are commonly used to drive the cryogenic compressors that liquefy the gas. The resulting liquid, shrunk to 1/600 of vaporized volume, is held at 3 ½ psig in insulated tanks for transport by pipeline or tanker.

Export facilities with liquefaction units, compressors, pipelines, and berths are not cheap, and the time needed to get from licensing, design, and construction to actual production can be as much as ten years. LNG plants require licenses from the U.S. Federal Energy Regulatory Commission for construction and from the Department of Energy for export.

"It'll cost at least between $2 billion and $4 billion or more for an export facility," Rodiek said. "If it is a brownfield, you can get to the $1 billion to $2 billion range. A few years ago we were looking to build import structures for gas from the Middle East. That has changed overnight."

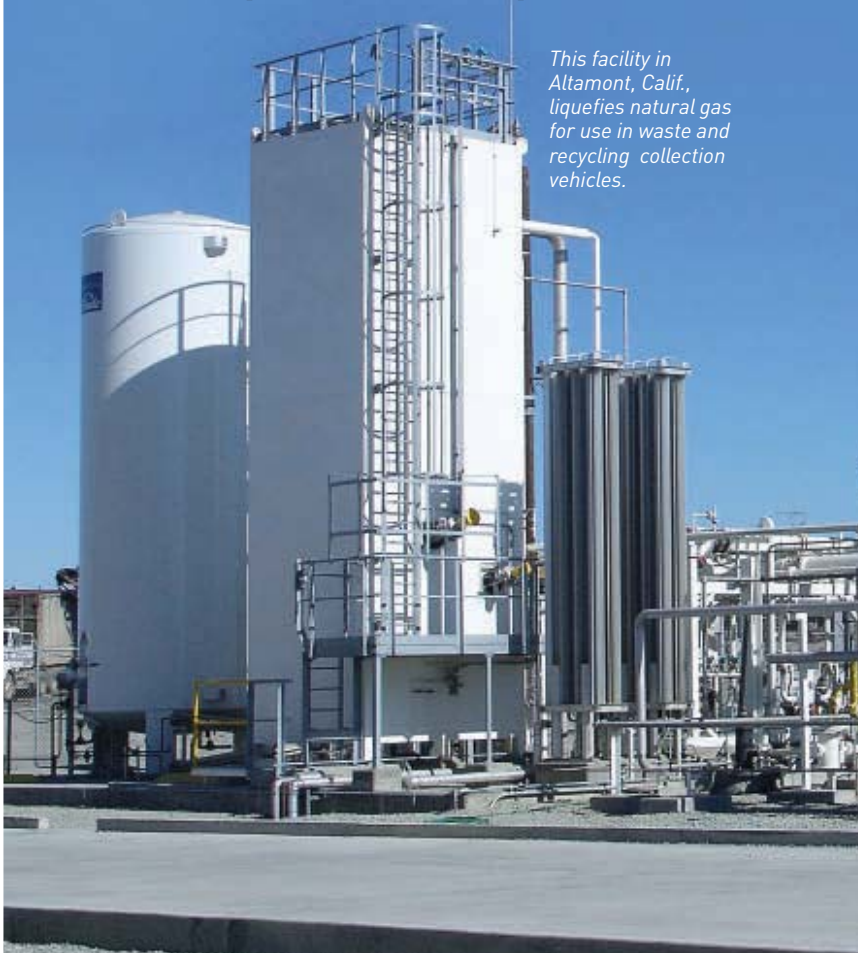
Multibillion-dollar export facilities in Louisiana and Oregon are moving forward, and another in British Columbia, to be fed by gas from Canadian shale formations, is under construction. These projects are backed by supply contracts with South Korea, the world's second-largest importer of natural gas, and Japan, which has increased its demand for LNG since a 2011 earthquake and tsunami disrupted that country's nuclear industry.

Cheniere Energy Inc. is adapting its Sabine Pass import terminal in Louisiana to make it "bidirectional." The company can use the site's five storage tanks and two berths for deepwater ships for either import or export, and the 94-mile Creole Trail Pipeline will be reconfigured to handle gas coming and going. The company is spending almost $8 billion on four liquefaction trains, each of which can handle up to 4.5 million tons per year.

The terminal's location near unconventional gas plays in Texas and Louisiana and interconnections to interstate and intrastate pipelines improve the site's economics, company officials say.

In nearby Hackberry, La., Cameron LNG is in final permitting to build three liquefaction trains capable of treating 12 million tons a year of LNG. Cameron said its cost is expected to be between $9 billion and $10 billion, and includes a new 21-mile pipeline, compressors, and modifications to existing pipeline interconnections. Construction is expected to begin later this year.

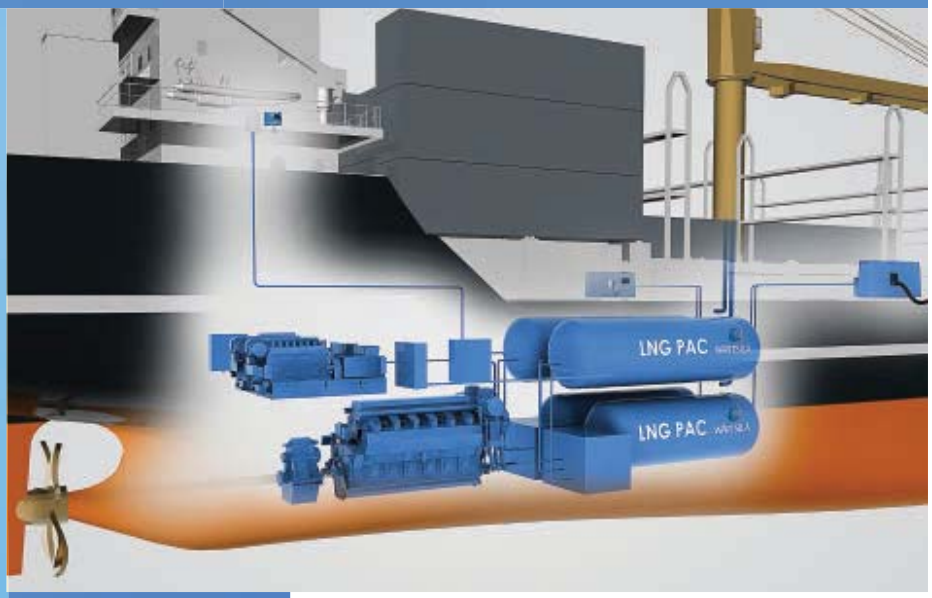
Cameron is adding the liquefaction capacity to its import facilities. There are two berths capable of handling Q-Flex type LNG ships, the second-largest LNG carriers, capable of carrying 210,000 to 217,000 cubic meters. The "Q" is derived from Qatar, where in 2007 Qatar Gas commissioned the first of 45 giant ships to transport LNG from new production facilities to Europe.



This facility in Altamont, Calif., liquefies natural gas for use in waste and recycling collection vehicles.

This is one of the most exciting times in energy in the U.S. I've been in the business since 1991 and I've never seen anything like it.

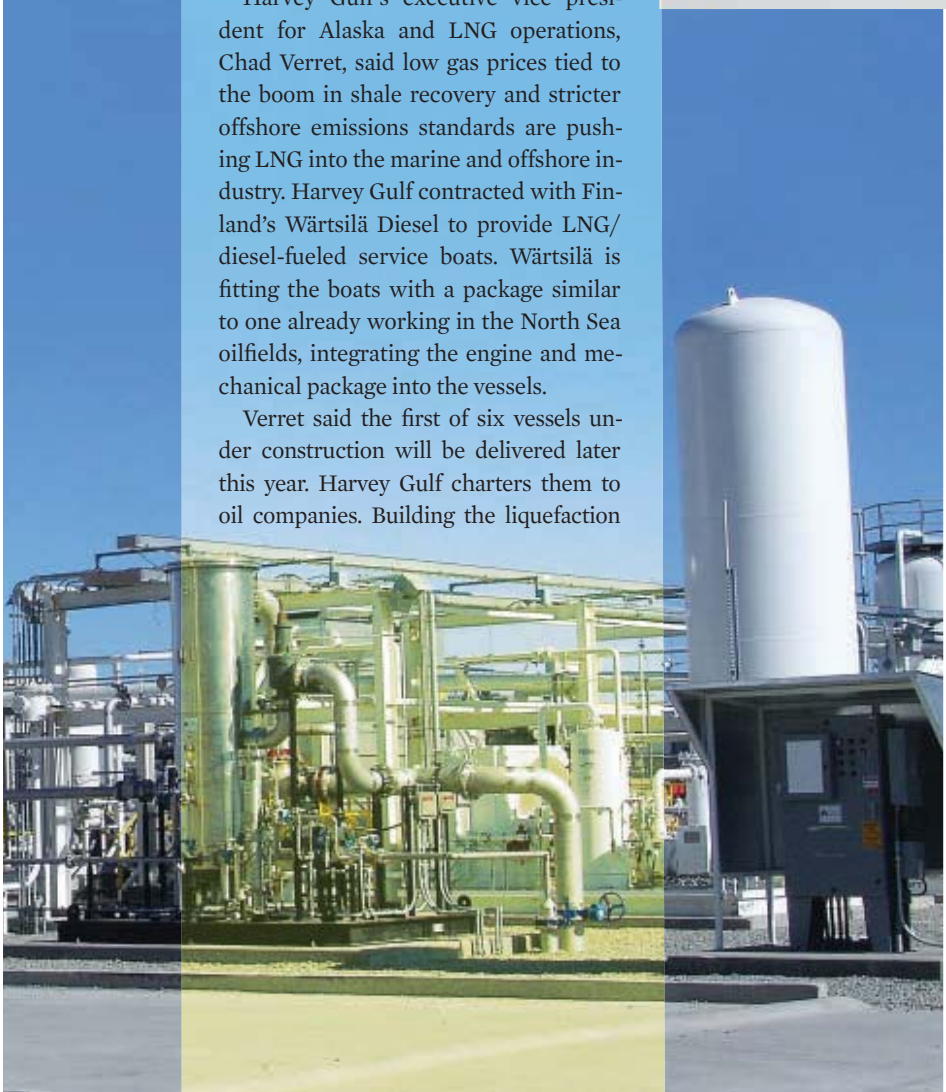
Wärtsilä has developed fuel storage and propulsion systems (shown in diagram) to enable service boat engines to run on LNG as well as diesel.



East of Hackberry and Sabine Pass, there is construction of another kind at Port Fourchon. Harvey Gulf International Marine decided earlier this year to build an LNG fueling facility at its Port Fourchon terminal. The $25 million first phase is the first of its kind in the U.S., and is being built in conjunction with the company's $350 million program to build a fleet of dual-fueled service boats for the offshore industry in the Gulf and elsewhere. Harvey Gulf will use two sites, each with 270,000 gallons of LNG storage capacity and capable of transferring 500 gallons of LNG per minute.

Harvey Gulf's executive vice president for Alaska and LNG operations, Chad Verret, said low gas prices tied to the boom in shale recovery and stricter offshore emissions standards are pushing LNG into the marine and offshore industry. Harvey Gulf contracted with Finland's Wärtsilä Diesel to provide LNG/diesel-fueled service boats. Wärtsilä is fitting the boats with a package similar to one already working in the North Sea oilfields, integrating the engine and mechanical package into the vessels.

Verret said the first of six vessels under construction will be delivered later this year. Harvey Gulf charters them to oil companies. Building the liquefaction trains "guarantees fuel availability" and helps customers meet emissions requirements, he said.



The general marine and rail market remains "about five to ten years out," said Srikanth Balasubramaniam, director of Cummins Inc.'s high horsepower natural gas business. Cummins, in Columbus, Ind., has been manufacturing natural-gas-fueled engines since the mid-1960s for off-highway vehicles and since the mid-1980s for on-highway vehicles.

On land, Cummins and others are seeing movement away from diesel engines toward either dual-fuel or gas-fueled engines. "All traditional diesel markets are showing interest," Balasubramaniam said. "Economics is the primary motivation but there are emissions advantages there too."

According to Roe East, Cummins' general manager for heavy duty/mid-range business, "The drivers for all of our customers are the three 'E's: economics, environment, and energy policy. In the U.S. now, growth is focused on economics."

The economic motive is a recent development, East said. Until recently the

The Wärtsilä 46DF engine can produce as much as 1,145 kW running on LNG aboard a ship or offshore platform.

market was "mostly things like urban buses faced with stringent emissions limits," he said.

Within the past year, United Parcel Service has announced plans to expand its fleet of LNG-capable heavy 18-wheel rigs to 800 by the end of this year, from 112. The UPS rigs will be fitted with Cummins engines, produced in joint venture with Westport Innovations of Vancouver, British Columbia.

The engines can run on liquefied or compressed natural gas. "The engine doesn't care," East said.

LNG is the generally preferred form of natural gas for use in long-haul heavy duty trucks because liquefying it reduces volume. More fuel can be loaded into the tank. Local-use vehicles, which operate from a central yard, often use CNG. Refuse trucks, for instance, commonly travel a designated route and return to the yard at the end of the day. Because refuse trucks get extremely low mileage, only 4 to 6 mpg, natural gas allows the firm to realize significant savings in fuel costs, East said.

Waste Management Inc. two years ago announced it will convert its entire fleet of 18,000 refuse collection vehicles to natural gas. More than 3,000 of its heavy-duty trucks are now fueled by natural gas and the company is buying 800 natural-gas-fueled vehicles per year. Officials also report the firm has built 58 fueling stations around the U.S., many of them open to the public.

Natural gas-fueled trucks cost about $30,000 more than their diesel counterparts, but at current fuel prices will make up almost the entire difference in a year, Waste Management's executives say. They estimate that each truck will save $27,000 in fuel costs annually.

✦ **Heavy-duty LNG-fueled** highway trucks could jump to 10 percent of the market in five years, East believes, up from 1 percent today. One challenge is the lack of refueling infrastructure. At present, most LNG fueling stations are in California, but companies are working to expand the availability of the fuel. Clean Energy Fuels, the largest natural gas provider for transportation fuel in North America, is installing fueling equipment at about 500 locations throughout the country.

GE Oil & Gas is moving into the market with its "LNG in a Box," a small-scale, self-contained fueling unit aimed at service centers. The unit is designed to produce 10,000 to 50,000 gallons, or 16 to 18 tons, per day of LNG, and includes a gas pretreatment system, cold box assembly, and compressors. Typical fuel tanks for heavy-duty vehicles hold between 70 and 150 gallons (110 to 240 kg). GE believes one 10,000-gallon-per-day system could fuel up to 100 trucks per day. Its first modular-constructed units were delivered to Europe through Luxembourg-based Gasfin.

Trucking isn't the only land transport system that could benefit from LNG. As long ago as the 1980s, the old Burlington Northern Rail-

GE and Caterpillar have developed a locomotive (right) that can run on liquefied natural gas. Many heavy-duty vehicles, such as the garbage truck below, are converting to LNG to cut emissions.

LNG fueling infrastructure, such as this gas station in Long Beach, Calif., is built along busy trucking and shipping corridors.

road used LNG-powered locomotives on some routes. Now GE and Caterpillar are both working to revive the concept by developing dual-fuel or dedicated LNG locomotives. Three major freight railroads—Burlington Northern Santa Fe LLC, Union Pacific Corp., and Norfolk Southern Corp.—are interested.

BNSF is beginning a pilot program. According to its executive chairman, Matthew K. Rose, the pilot program is "an important first step that will allow BNSF to evaluate the technical and economic viability of the use of liquefied natural gas in through-freight service."

Savings could be huge. In 2012 Union Pacific reportedly spent $3.6 billion on fuel, and natural gas promises to reduce those costs considerably. Railroads expect retrofit kits to convert diesel locomotives to dual fuel will come to market first. Rail executives expect retrofits to be cheaper than the cost of a new locomotive, about $2 million.

One retro item is a fuel car to store LNG and feed it into the locomotive, a 21st-century take on coal tenders that fed steam locomotives. The American Association of Railroads has already put together a task force to review safety standards as well as to ensure that LNG-fueled engines can be used across rail networks.

The railroads will have to bring along partners to provide fuel infrastructure, and some companies are stepping in. GE also provides what it calls MicroLNG units, a larger version of LNG in a Box. The modular liquefaction plant can produce between 50,000 and 450,000 gallons per day of LNG. The company has already sold two units to Clean Energy Fuels Corp. to supply its growing California fueling network.

✦ **For LNG, the only serious limits** that people are talking about today are related to infrastructure costs, particularly in the development of exports. Even if the international demand for LNG stays high, exports from the United States can't happen for a few years because of the time needed for plant construction.

Pierre Bechelany, senior vice president of pipelines and LNG for Fluor Corp., said, "I think we're looking at forty to fifty million tons being exported eventually by the U.S. Globally, we're told energy will grow at 5 percent per annum until 2025, and [in North America] in a little over ten years to double capacity." Bechelany adds that meeting the demand to build new energy projects will challenge the engineering, procurement, and construction industry, and not every export facility now in the planning and permitting stages will be successful.

"The U.S. is well positioned," he said. "Certainly four or five plants will go forward," although he sees difficulty in obtaining capital for some projects lagging behind the leaders.

Still, optimism reigns among players throughout the natural gas industry. According to Statoil's Thorstein Hole, "For the bigger picture, you have to be open to all possibilities for product. And I am very encouraged by the attempts we're seeing for developing LNG." ME

JOHN KOSOWATZ is a senior editor at ASME.org.

whisper + ROAR

IN A CROWDED MARKETPLACE, companies must differentiate themselves—even if that means stretching the truth a bit. Manufacturers of snack foods often trumpet healthy aspects of their product—Fat Free! Gluten Free!—even if it is full of added sugars and preservatives.

In the 1960s, Eastern Airlines introduced the "Whisperjet" (below) as a marketing gimmick. Bombardier's CSeries planes (above), powered by Pratt & Whitney geared fan jet engines, are the real deal.

AS THE GAS TURBINE INDUSTRY PROGRESSES, RAW POWER ISN'T THE ONLY IMPORTANT METRIC.

BY LEE S. LANGSTON

Airlines aren't much different. In 1964, Eastern Airlines began a service it called "Whisperjet" using Boeing 727s with rear-mounted engines. "Quiet as a library," one of the television ads promised, right after running through the menu choices of lobster Newburgh and filet mignon.

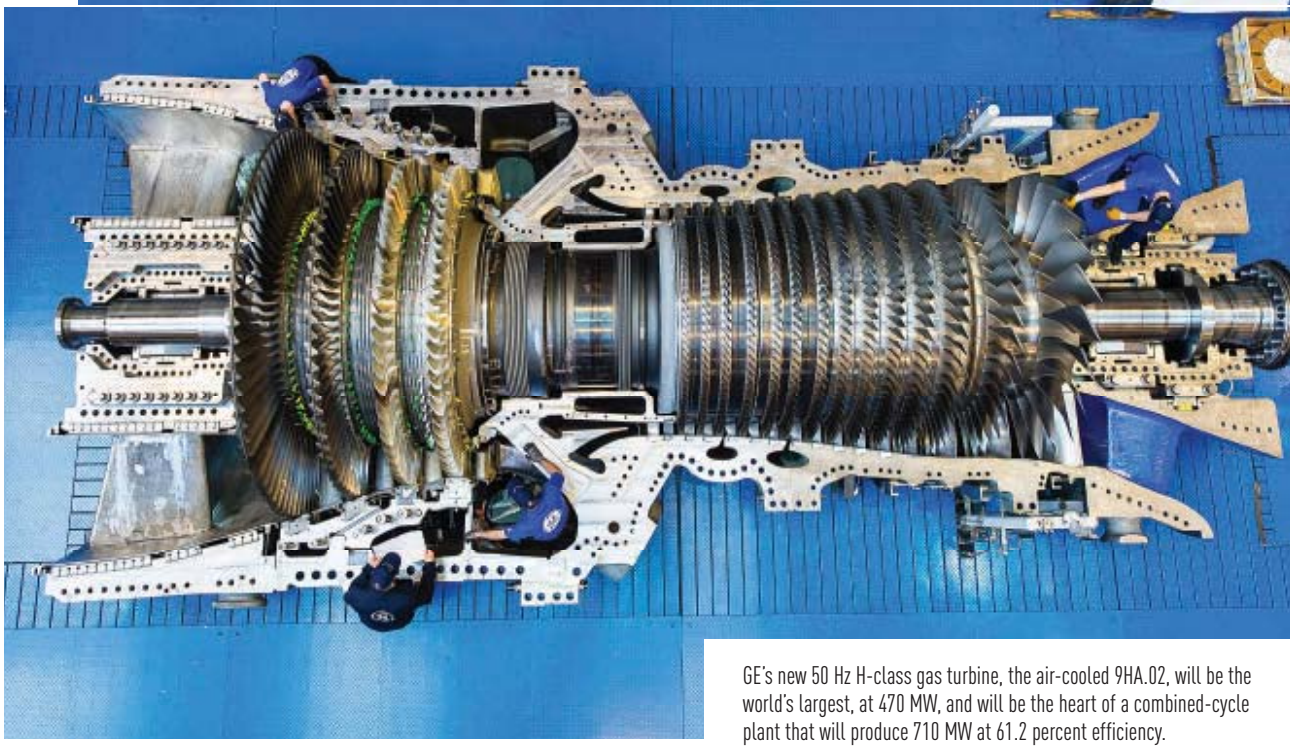
The food may have been fancy, and for those riding in first class, engine noise may have been reduced. Somewhat. But the Pratt & Whitney JT8D-200 engines themselves were every bit as deafening as every other jet engine of that era.

Fifty years later, things have changed. The Whisper Jet brand name is back, even if Eastern Airlines is long gone. It's being revived by Porter Airlines, the major carrier out of Billy Bishop Toronto City Airport. The popular airport, which handles 2 million passengers annually, has had a city-imposed ban on jet engine use for scheduled airlines since 1983. They are too noisy for the downtown location.

Porter has petitioned Toronto authorities to exempt from the ban the 12 Bombardier CS100s it has ordered. The 107-passenger CS100s are powered by two of P&W's new PW1500G geared turbofan engines. Although the engine provides 20,000 pounds of thrust, due to its large-diameter, geared-down, lower-rpm fan, less fan noise is generated. The resulting lowered-velocity exiting fan bypass air provides for greatly diminished jet noise. The characteristic turbofan whine is gone, replaced instead by a "whoosh".

All told, the GTF puts out half the noise of similarly sized jet engines, and thus a sound footprint only a quarter as large. (There is also a 16 percent reduction in fuel consumption.) Some engine people claim that the GTF engines should be even quieter than the currently permitted Porter turboprops. These would be Whisper Jets that could live up to the name.

Here one can see that noiselessness could mean big money. If approved, Porter Airlines Whisper Jets could offer direct flights to Vancouver, Florida, or the Caribbean, now beyond the reach of Porter's short-haul turboprops. Airport staff estimates that introduction of such GTF flights could double passengers handled at Billy Bishop, to well over 4 million annually.



GE's new 50 Hz H-class gas turbine, the air-cooled 9HA.02, will be the world's largest, at 470 MW, and will be the heart of a combined-cycle plant that will produce 710 MW at 61.2 percent efficiency.

Pratt & Whitney's geared fan PW1000G family will also be powering other new single-aisle, narrow-bodied aircraft in the coming years. These include the Airbus 320neo, the Mitsubishi MRJ, the Embraer E-Jet, and the Irkut MC-21. When airport neighbors and passengers—especially those at congested hubs like London's Heathrow—hear the marked reduction in takeoff and landing noise from geared fan turbojets, one can speculate there will be more public pressure to quiet other jet aircraft.

THE WISDOM OF A GEAR BOX for a jet engine fan wasn't always obvious. For instance, the keynote session of IGTI's 2005 Turbo Expo in Reno featured the president of Pratt & Whitney, who reported on progress with the geared turbofan after ten years of development. During the discussion afterwards, retired CEOs from rival GE Aircraft Engines and Rolls-Royce both stated that based on their experience such systems were to be avoided. The consensus was that Pratt was following a dead end.

That consensus has now reversed. Rolls-Royce recently announced that the company will pursue large geared turbofan designs for their next generation engines for the 2020s. And with its GTF, Pratt is taking aim at the engine maker that dominates the single-aisle, narrow-body market: CFM International.

Jointly owned by GE Aviation and SNECMA, CFM International has sold some 23,000 CFM56 engines in the last 35 years. These engines, in the 30,000 lbt range, power most of the Boeing 737 and Airbus 320 families, the current duopoly aircraft of SANB. Both Boeing and Airbus are projecting that SANB will be a $2 trillion dollar market for the next 20 years, accounting for more than 23,000 airplane deliveries.

CFM International is countering P&W's GTF with LEAP (Leading Edge Aviation Propulsion), a high-bypass turbofan successor to CFM's very successful CFM56. The LEAP family is undergoing flight testing in 2014, and is scheduled for full FAA certification in 2015-16. The engines will then be entered into service on the Airbus 320neo, the Boeing 737 MAX and the Comac 919.

The LEAP engine will have a 15-to-16 percent reduction in fuel consumption, compared to the current CFM56. A higher bypass ratio and a higher compression ratio contribute to lower fuel consumption. LEAP's larger diameter fan is constructed of carbon fiber composites for light weight and durability, as is the encircling fan case.

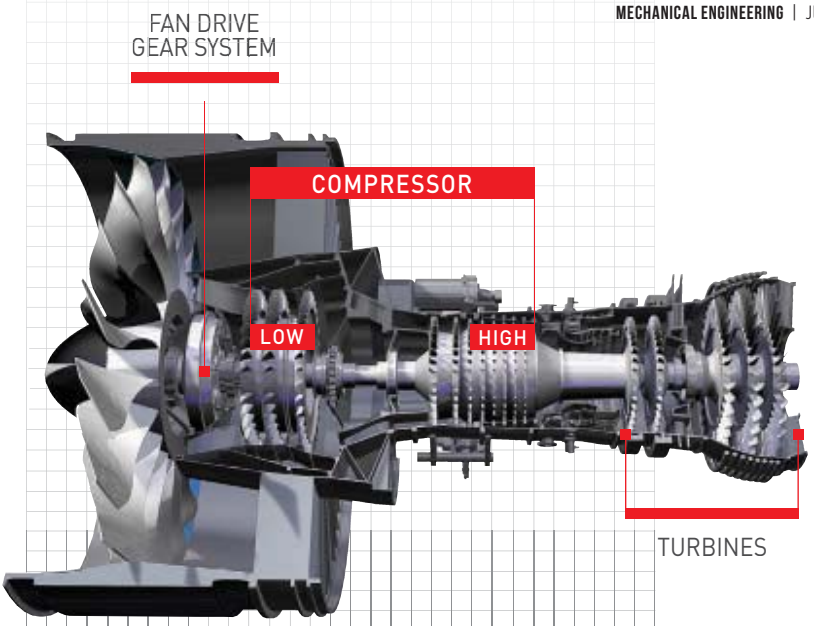
LEAP will also be the first commercial engine using ceramic matrix composites in its hot section. These composites, consisting of ceramic fibers embedded in a ceramic matrix, can be made as strong as metal and can withstand temperatures higher than heavier nickel-based superalloys. Endurance LEAP engine testing is being carried out to validate the new hot section technology, with over 5,000 cycles completed to date.

THESE TWO COMPETING turbofan engines, the GTF and the LEAP, are part of a much larger global gas turbine market, which is broken down into two segments, those manufactured for aviation and those for non-aviation applications.

This year, 2014, marks the diamond jubilee for both segments. 1939 was a pivotal year in many fields: Hollywood produced both *Gone With the Wind* and *The Wizard of Oz*;

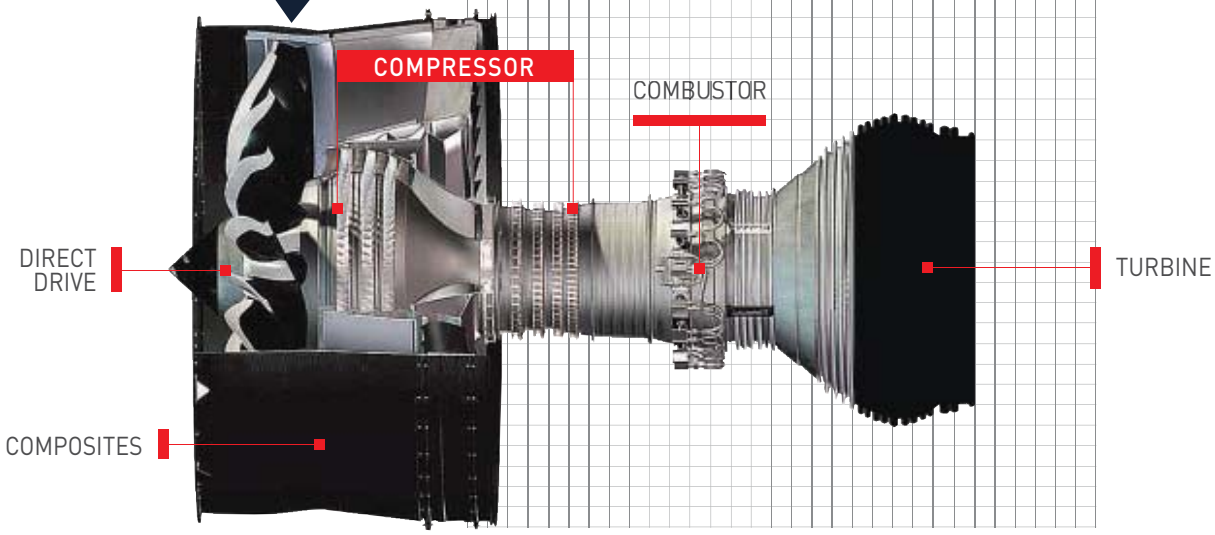
The 30,000 pound-thrust class Pratt & Whitney PW1100G geared fan jet engine, with a 12:1 bypass ratio and an 81-inch diameter fan, will power the Airbus 320neo.

GTF



The 30,000 pound-thrust class CFM International LEAP-1A jet engine, with an 11:1 bypass ratio and a 78-inch diameter fan, will also power the Airbus 320neo.

LEAP



The Grapes of Wrath and *Finnegans Wake* were both published; fission was discovered and nylon was introduced. And with gas turbines, there were two seminal events in 1939. The first non-aviation gas turbine was completed and tested under full load on July 7, 1939, by the Swiss firm, Brown Boveri; it powered a 4 MW electrical generator for installation as a power plant in the Swiss city of Neuchâtel. (A new book, *Gas Turbine Powerhouse* by Dietrich Eckhardt, details the history of this first gas turbine power plant, Brown Boveri, and a multitude of other gas turbine projects.) The next month saw the first aviation gas turbine powered flight take place over the Baltic Sea. That first jet plane, the single-engine He178, flew out of the Heinkel Aircraft Company airfield at Rostock-Marienche, Germany, on the morning of August 27. A few days later, the German army invaded Poland.

Over the intervening 75 years, gas turbines have become a major energy converter, both in aviation and non-aviation applications. One way to gauge their influence is to look at recent gas turbine industry financial history. Using computer models and an extensive data base, analyst Bill Schmalzer of Forecast International in Newtown, Conn., has provided the values of gas turbine manufacturing production from 1990 to 2013, and has projected values to 2028. (FI considers value of production figures to be more accurate than reported sales figures.)

Schmalzer reports that the value of production for gas turbines worldwide was $65.7 billion in 2013, up from $61.7 billion for 2012. By 2028, that's projected to increase to $88.7 billion in constant dollars, up some 35 percent from 2013. FI's value of production history and predictions do indeed show that the gas turbine has been and will be a global growth industry.

FI's gas turbine value-of-production history and predictions from 1990 to 2028 show a steady, essentially monotonic growth for the aviation segment, which is now two thirds

of the industry. In 2013, the value of production of gas turbines for commercial aviation was $37.9 billion, while $6.3 billion was for military jets.

When one considers there are about 19,500 airplanes in the worldwide air transport fleet and almost all are powered by gas turbines, it is obvious why commercial aviation dominates the aviation engine market. The much smaller military gas turbine market, however, is crucial to the development of commercial gas turbines.

From the first flight of the He178, the very first jet planes were military fighters, from which commercial engines were developed. Right now, one of the most technologically advanced jet engines is the Pratt & Whitney F135, which powers the Lockheed Martin F-35 Joint Strike Fighter. Based on past history, the technology breakthroughs in the F135 should eventually lead to improved commercial gas turbines.

THE OTHER SIDE OF THE INDUSTRY—gas turbines for electrical power, mechanical drive, and marine applications—had a value of production in 2013 of $21.5 billion.

Marine gas turbines are used to generate electrical power for propulsion and shipboard use. For instance, the cruise ship *Queen Mary 2* has two General Electric LM2500 gas turbines, each providing up to 36 MW, in addition to its four diesel engines. The LM2500 is derived from General Electric's CF6 turbofan engine, used on Boeing's 747 and 767.

Natural gas pipelines provide a large market for mechanical drive gas turbines. To make up for frictional pressure losses in natural gas flow, compressor stations are located about 50 miles apart along a pipeline. The compressors are powered by gas turbines, which use pipeline natural gas as fuel.

But according to the data from Forecast International, about 85 percent of the value of production of non-aviation gas turbines is used for electrical power purposes. That segment of the gas turbine market can be volatile, as evidenced by a short-lived spike in the value of production of gas turbine electrical generating sets in 2001, caused by irrational market exuberance at the onset of electric utility deregulation. Post-spike

A supersonic F-35 Joint Strike Fighter in subsonic flight. Powered by a 40,000 pound-thrust class F135 jet engine, with both vertical and short takeoff and landing capabilities, the fighter is now in production.

behavior has shown a steady recovery and growth in electrical generation markets with the value of production in 2005 doubling by 2013 to $18.3 billion.

Combined-cycle electric power plants, made possible by the gas turbine, continue to grow in size and unmatched thermal efficiency. These plants combine the use of the gas turbine Brayton cycle with that of the steam turbine Rankine cycle. (They should more accurately be termed a combined power plant, because the thermodynamic cycles are not combined, but separate.) The gas turbine hot exhaust gases are used to generate steam to drive a steam turbine, with both turbines driving generators to produce electricity from one unit of fuel (usually natural gas), rather than two units, if separate.

General Electric just announced its new H-class combined-cycle air-cooled gas turbines, the 9HA.02 and the 7HA.02. *Gas Turbine World* reports that the air-cooled 9HA.02 will have a gas turbine output of 470 MW, a combined-cycle output of 710 MW at a quoted thermal efficiency of 61.2 percent. If reached, that efficiency mark will best the current record holder, a combined-cycle plant at Irsching, Germany, powered by a Siemens SCC5-8000H, which with a combined-cycle efficiency of 60.75 percent is the most efficient heat engine ever run.

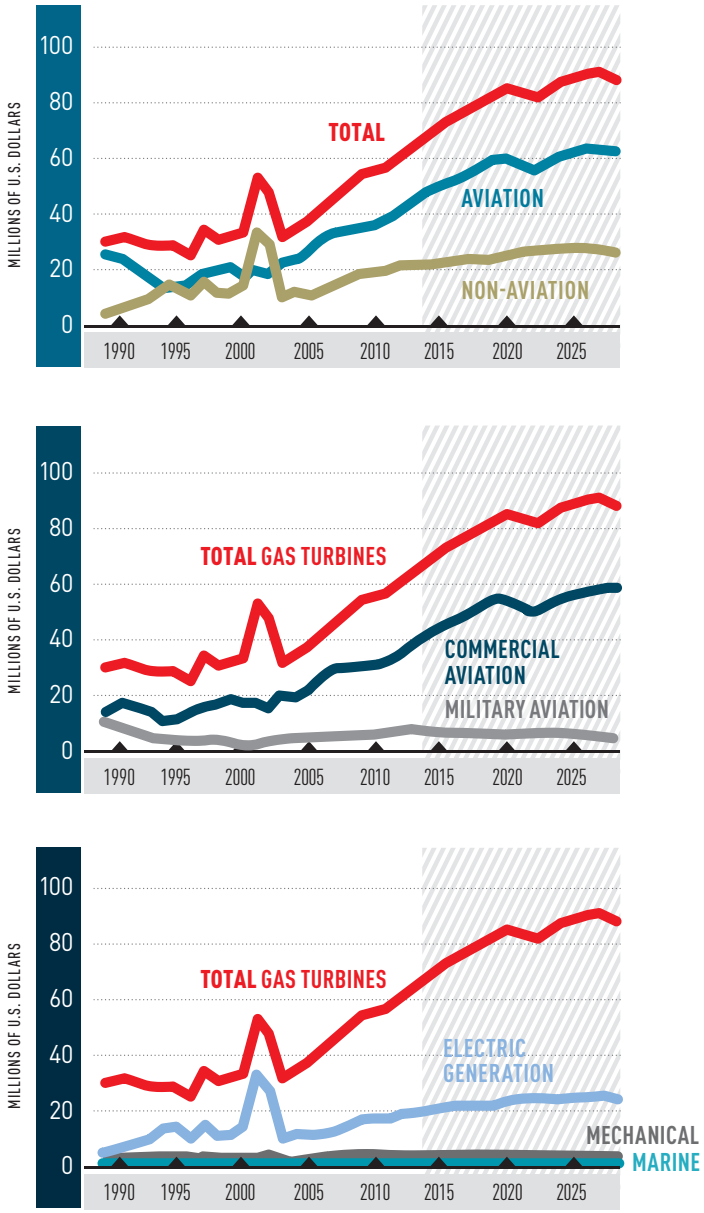
As future combined cycle plants are introduced, we can expect higher efficiencies to be reached. We'll need every gain we can get.

This year's Environmental Protection Agency Annual Report shows there has been a remarkable 10 percent drop in U.S. generated greenhouse gases, between 2005 and 2012. One major contributing factor to this reduction has been the nation's switch from carbon-rich coal to low-carbon natural gas in electricity generation.

Since almost all recent and new U.S. electrical power plants are powered by natural gas-burning, high-efficiency gas turbines, one has solid evidence of their contribution to the greenhouse gas reduction reported by EPA. This has led EPA to propose new fossil-fuel power plant regulations, which assume a baseline for the electricity sector in which new generation capacity comes primarily from modern, efficient combined-cycle, gas-fired turbine plants.

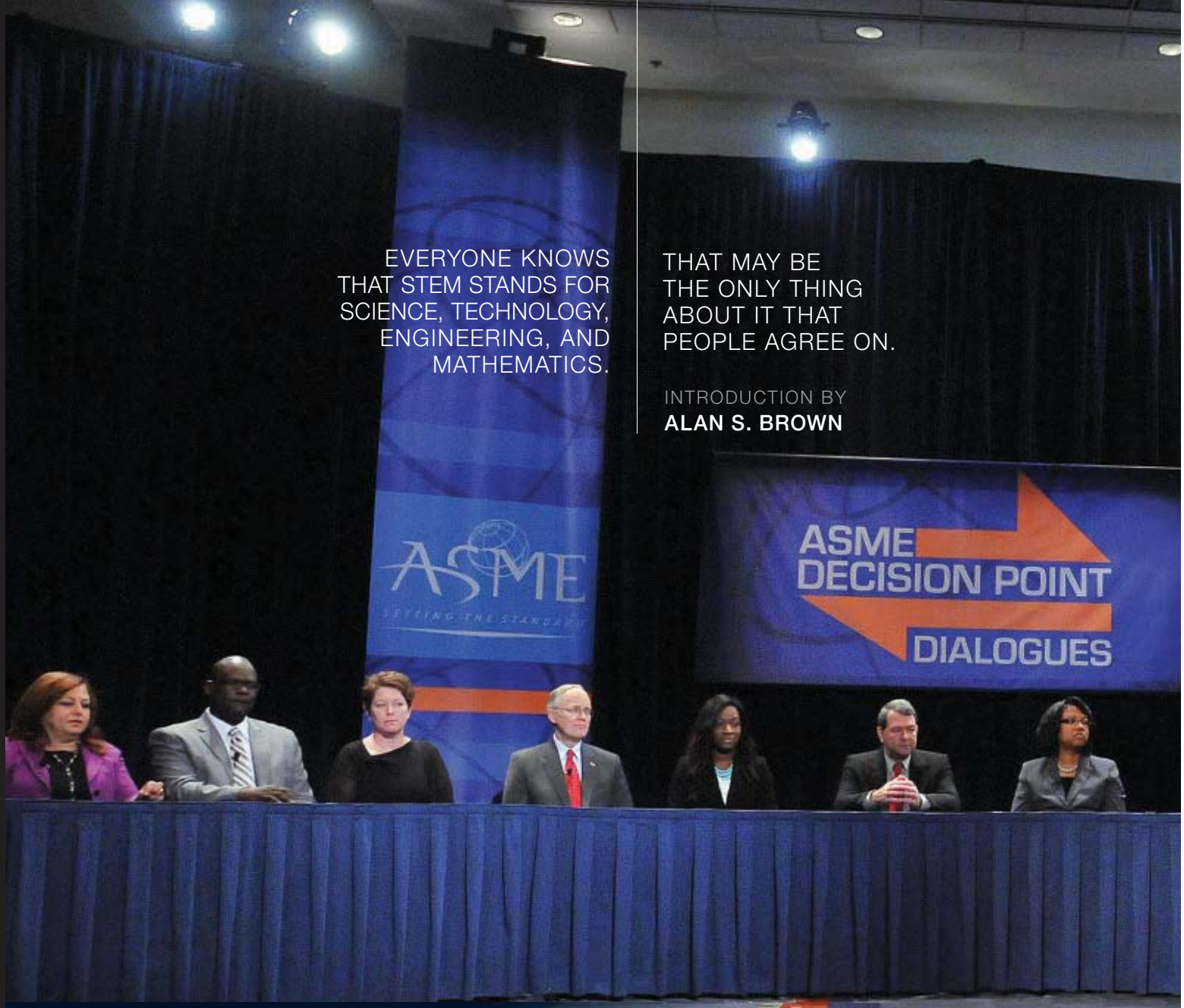
How much of an improvement would these plants provide? Natural gas itself has half the carbon emissions of coal on a per-Btu basis, according to the Energy Information Agency. So if coal-fired thermal power plants, with a fuel-to-electricity efficiency of around 33 percent, are swapped out for combined-cycle power plants with efficiencies on the order of 60 percent, it will lead to a 70 percent reduction in carbon emissions per unit of electricity produced.

Here's a case where the marketing superlatives are appropriate. Gas turbines really are a modern wonder. **ME**



This value-of-production data, provided by Bill Schmalzer of Forecast International, shows steady growth and a prediction of continued expansion.

LEE S. LANGSTON is an ASME Fellow and professor emeritus of the mechanical engineering department at the University of Connecticut in Storrs.



EVERYONE KNOWS THAT STEM STANDS FOR SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS.

THAT MAY BE THE ONLY THING ABOUT IT THAT PEOPLE AGREE ON.

INTRODUCTION BY
ALAN S. BROWN

GO TO **WWW.GO.ASME.ORG/DIALOGUES** FOR MORE ON THE ASME DECISION POINT DIALOGUES AND STEM. JOIN IN THE CONVERSATION AT **HTTP://BIT.LY/1SB8YPG.**

INNOVATION DRIVES THE AMERICAN ECONOMY, CREATING NEW TECHNOLOGIES, NEW JOBS, AND ENTIRELY NEW INDUSTRIES. EDUCATION IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS—WHAT EDUCATORS REFER TO AS STEM—DRIVES INNOVATION. THAT MEANS **GETTING STEM EDUCATION RIGHT IS ONE OF THE MOST IMPORTANT TASKS FACING THE U.S.**

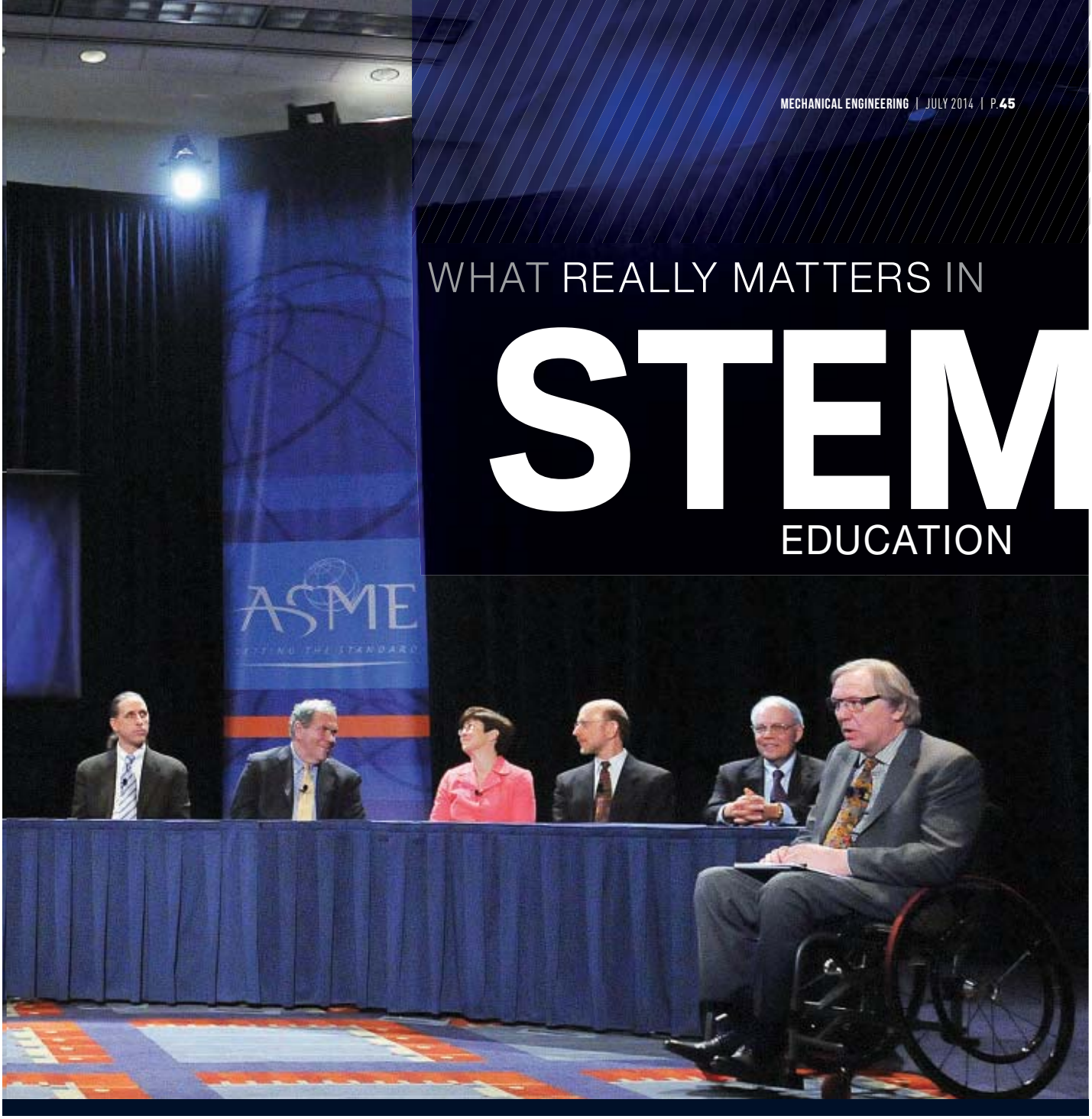
With stakes so high, it's not surprising that STEM education has become a battleground of ideas and philosophies.

Whether it's the qualifications of the teachers, the emphasis of the curriculum, or the resources devoted to the field, hardly anyone agrees on how—or even whether—to make changes. Some experts even suggest that there are so many technically trained graduates that some may never get a good job.

These challenges, triumphs, and contradictions were on display at *Critical Thinking, Critical Choices: What Really Matters in STEM*, a far-ranging discussion that featured 12 leaders in STEM education.

The forum focused on middle school, where students become teenagers and develop many of the in-

WHAT REALLY MATTERS IN STEM EDUCATION



terests and attitudes that will guide their life choices. This makes middle school a critical time for STEM educators.

The April 23 event kicked off the *U.S. News* STEM Solutions Conference in Washington, D.C.

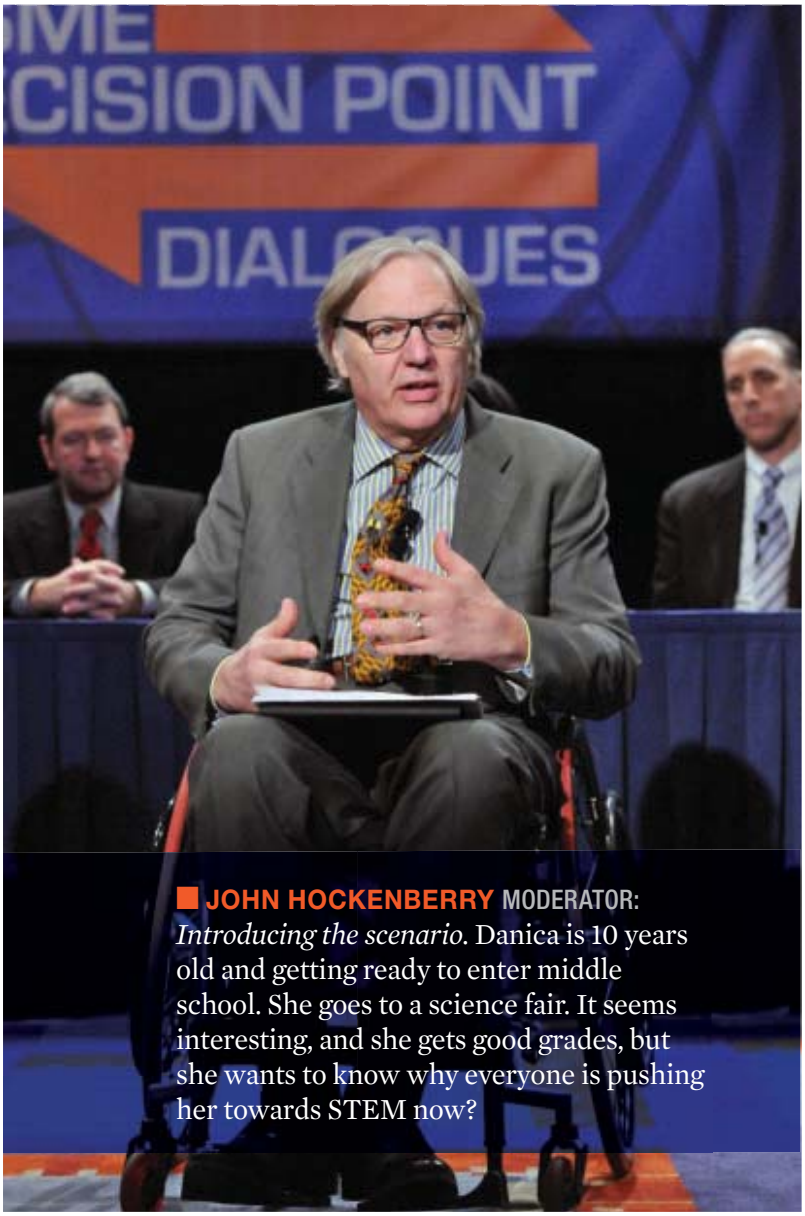
Critical Thinking, Critical Choices is part of the ASME Decision Point Dialogues thought leadership program, where leaders debate the complexities underlying an issue by focusing on the decisions people must make in real life.

Noted education experts such as Boston Museum of Science president Ioannis Miaoulis, former Vermont governor James Douglas, Girlstart executive director Tamara Hudgins, Wilson Foundation president Arthur Levine, National GEM Consortium executive director Michele Lezama, and award-winning journalist Pat Wingert participated in the event.

The conversation ranged from how to serve disadvantaged communities and the role of testing versus project-based learning to the contentious Common Core and Next-Generation Science Standards.

Unlike typical conference sessions, the panelists' opinions were challenged by other panelists and the moderator, Peabody and Emmy Award-winning journalist John Hockenberry. His pointed questions kept the heat on the panelists, forcing them to justify their answers and spell out the tradeoffs their choices entailed.

The following six pages provide selections from the two-hour discussion. ASME.org is broadcasting the forum online at www.go.asme/dialogues. »



JOHN HOCKENBERRY MODERATOR: *Introducing the scenario.* Danica is 10 years old and getting ready to enter middle school. She goes to a science fair. It seems interesting, and she gets good grades, but she wants to know why everyone is pushing her towards STEM now?

MADIHA KOTB ASME PAST PRESIDENT: Getting good grades is not enough. You have to have a passion for it. And you will, when you hear all the good things engineers do and all the differences we make in people's life. Danica, I see the excitement in your eyes. Why don't you come and spend a day with me at work? You will see what my life is like. We touch so many different things. I'm a mechanical engineer and I have done more in my life than I could ever imagine doing. Give it a chance. Be open minded.

KENNETH WILLIAMS TEACHER, OXON HILL MIDDLE SCHOOL, FORT WASHINGTON, MD: One of the big problems that I had as a former math teacher was that before I even got an opportunity to introduce myself, the mother is already apologizing because she had poor success in mathematics. This gives automatically gives the child standing next to her a reason not to perform to my standards, because he comes from a long line of math illiterates.

HOCKENBERRY: What do you do about that?

WILLIAMS: I have to engage him where he is at. So if basketball is his thing, I may even go to the gym, ask him to shoot 10 foul shots, and begin to talk about mean, median, and mode, or why his shot goes higher if he holds his arm differently. I also have to give some support to the mom. We have programs to help his mom learn math. I am not expecting Derek to become Isaac Newton, but I want him to have more confidence in his mathematics.

▲ **HAL SALZMAN** PROFESSOR OF PUBLIC POLICY, RUTGERS UNIVERSITY: I think we are pushing all of these kids into STEM, thinking that there is a career option. It's great to be scientifically literate. But if we think it's because there is a job market out there, we are deluding ourselves and doing a disservice to all of us who want to see strong STEM education.

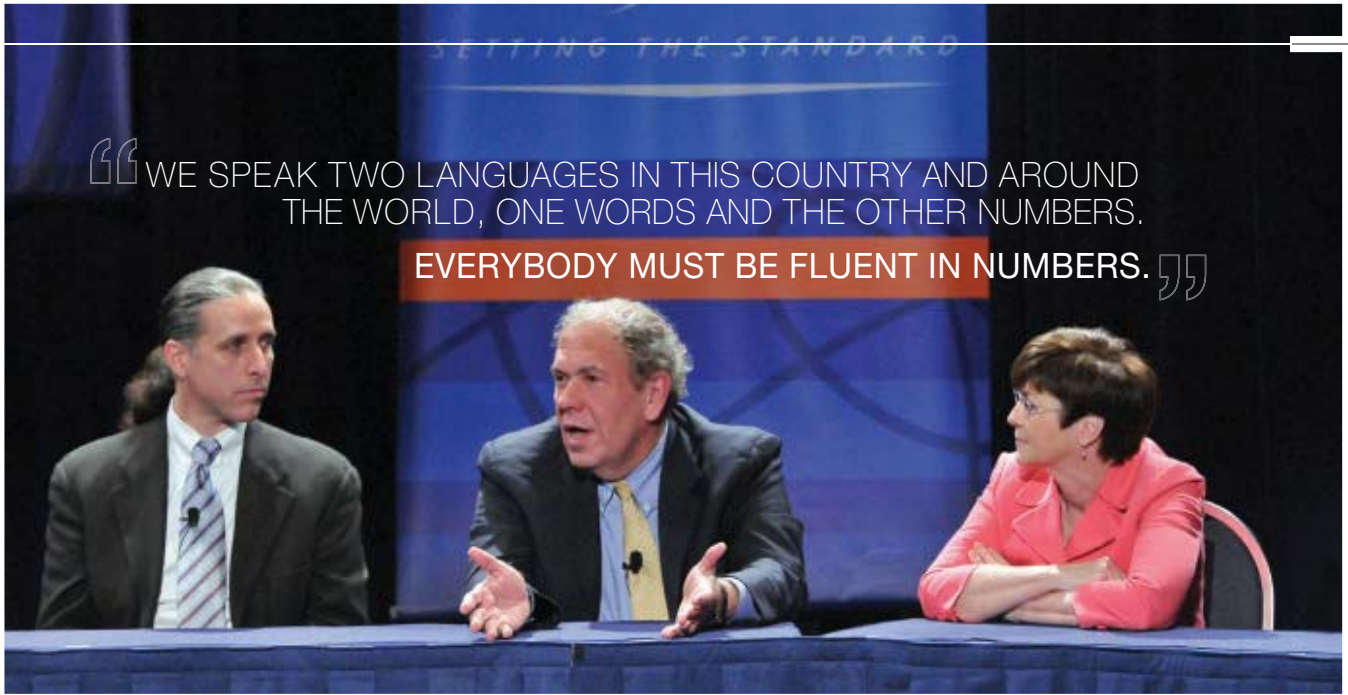
HOCKENBERRY: Wait a minute. There is no STEM crisis? No urgency?

SALZMAN: We are not lacking for STEM graduates or STEM workers in this country. It is quite the opposite, particularly at the higher levels. In life sciences, it has become a lottery to get a job. Maybe 20 percent of Ph.D.s in biology are getting good job opportunities. Most of them are not going to get the kind of job they all hope for.

We need to think about our goals. Is there really a great payoff in the job market? For some kids, there is. For most of them, there probably isn't. So we have to think about STEM for a different reason. Why do we want STEM?

▼ **ARTHUR LEVINE** PRESIDENT, WOODROW WILSON FOUNDATION: I think there are probably four things we should expect from STEM education. First, we speak two languages in this country and around the world, one words and the other numbers. Everybody must be fluent in numbers. Second, as citizens in a democracy, we will need science to achieve a fundamental understanding of all kinds of public issues coming our way.

Third, there is a whole set of mid-level jobs, not engineers and scientists, but sub-engineers and sub-scientists, that will require STEM skills. And finally, if we are going to remain competitive in this world, we need a critical mass of industry and a critical mass of labor to fill the jobs in that industry.



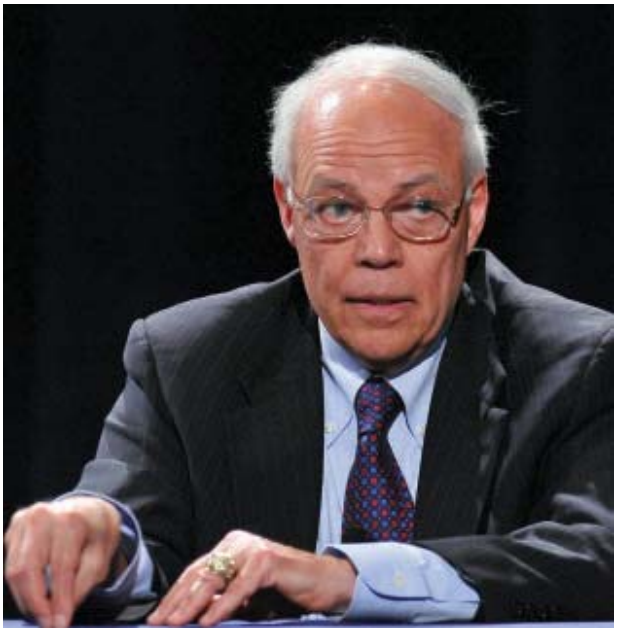
◀ **IOANNIS MIAOULIS** PRESIDENT AND DIRECTOR, BOSTON MUSEUM OF SCIENCE: The science curriculum focuses almost entirely on the natural world. And if we look at the world around us, I would argue that it is mostly engineering.

Why is engineering not part of the regular curriculum? The U.S. curriculum we teach today was decided in 1893 by the Committee of 10 at Harvard University. They left engineering out because, in 1893, most engineering was agricultural engineering and kids grew up on farms and were learning it at home.

So they issued the report and the curriculum has never been touched. So now, kids spend endless time learning how many legs a grasshopper has, but they have no clue how a faucet works, how a car runs, or how a plane flies. I would turn the whole science curriculum upside down, introduce engineering as a core discipline, and teach it from first grade all the way up to high school.

▶ **REGIS MATZIE** CHIEF TECHNOLOGY OFFICER (RETIRED), WESTINGHOUSE: I think many students don't see the relevancy of some of the things they are studying. So it is important for teachers to show the relevancy of math or science by applying it to something their students deal with or play with or see every day. I think that relevancy can inspire students.

▼ **MARK CONNER** DIRECTOR OF ONLINE ENGINEERING AND ENGINEERING ACADEMIES, HOOVER (ALA.) HIGH SCHOOL: So let me bring in an air of cynicism to this. What if the reason



is that teachers don't know how to answer the question, "When will we ever use this?" I would contend that they are a large percentage of our teaching population. They can't bring relevance because they have never been outside of the education silo. They came through our public education system. They got an education degree. Then they went back into the public education system.

MATZIE: I think we need to reach out for other resources, people from industry, parents with experience, curriculum specialists. We could bring in a bunch of resources.

HOCKENBERRY: What technology would you buy for your school?

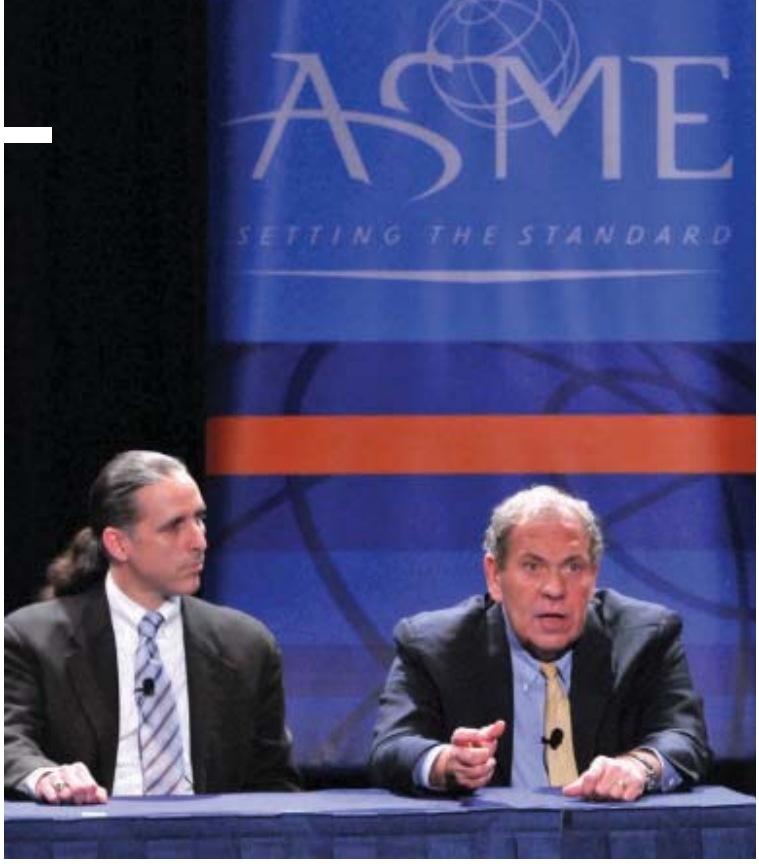
▶ **TAMARA HUDGINS** EXECUTIVE DIRECTOR, GIRLSTART: A 3-D printer. First, because it is amazing to make stuff. Second, it is amazing to have the experience of getting a really great idea with a friend—a cruise ship or a Hogwarts location —creating it on paper, and then taking it into a virtual environment and seeing that idea manifest. Most children, and most adults, I would submit, find it challenging to put what is in their mind into physical reality. When you see 3-D printing make manifest someone's ideas, it is really exciting.

MIAOULIS: Absolutely, I would invest in a 3-D printer, but also in a small engineering laboratory that includes other things. Greenwich Academy, a private girl's school in Connecticut, has one, and there are three times more girls trying to get into it than the laboratory can handle. I would like to see engineering be that big in all schools.

"THE COMMON CORE IS TRYING TO EMULATE WHAT SUCCESSFUL COUNTRIES DO, **TAKING OUR TIME AND DEVELOPING A MUCH DEEPER UNDERSTANDING.**"

▶ **PAT WINGERT** JOURNALIST, HECHINGER INSTITUTE ON EDUCATION AND THE MEDIA: I think that there is a misconception that in Singapore, the kids are sitting there and teachers are just shoving information into them. In reality, in Japan, in Singapore and Taiwan, when they teach math, they give those kids an everyday problem. Then the teacher basically leaves them alone for half an hour and lets them struggle with the solution. They will try this and try that, but they get invested the longer they try. It isn't until the end of the class that they start sharing ideas and the teacher starts a discussion.

Most of us can remember our own math class. The teacher gave us maybe one or two minutes, then jumped in and said, "Here is the trick to getting it fast." Were you emotionally invested? No. Do you even remember that trick? No. The Common Core is trying to emulate what successful countries do, taking our time and developing a much deeper understanding.



HOCKENBERRY: Arthur, imagine you're an engineer and STEM teacher whose wife lost her job. You have a job offer that pays almost twice your teacher's salary. Commiserate with Mark.

LEVINE: I can't afford to keep this job. The longer I do it, the lower my salary when compared to people with the same credentials. I have a mortgage. I want to send my kids to college. I like doing this a lot, but I can't afford to keep doing it.

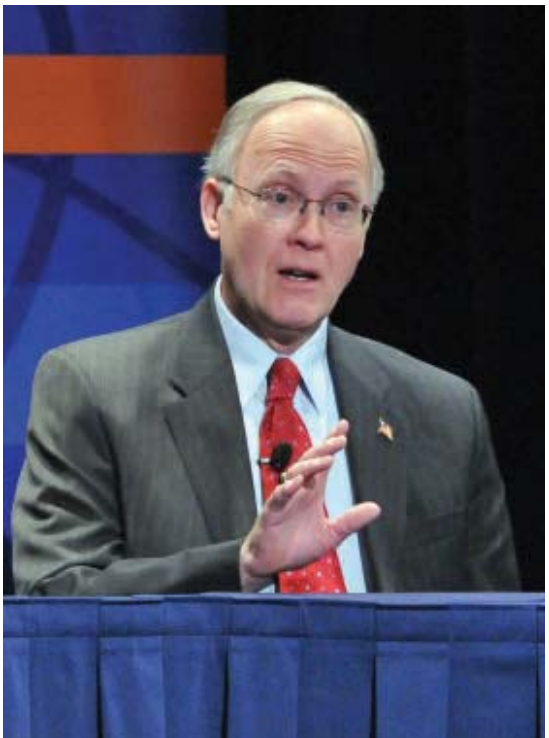
CONNER: I feel your pain, but this is reality. Reality is that there is nothing you can do as a teacher to bump your pay up. You don't get paid more for doing a better job. Once you hit a certain point in your career, your salary actually decreases. Not relative to everybody else, but to what you made last year.

HOCKENBERRY: What do you say to try to keep him?

CONNER: I don't, because I have children and a wife. If I can't support them, it doesn't matter how much I love it.

HOCKENBERRY: Governor, would you sign a bill that paid teachers a lot more?

▼ **JAMES DOUGLAS** GOVERNOR OF VERMONT (2003–2011): It depends on what else was in it.



HOCKENBERRY: That's all that is in the bill.

DOUGLAS: Our state has one of America's highest property tax burdens. We have a declining student population. Budgets are going up. There are lots of other moving parts.

HOCKENBERRY: What about a bill to pay STEM teachers more?

DOUGLAS: I would like to do it. But there has to be cost controls on the total cost of public education. It is out of control in our state.

HOCKENBERRY: Not hearing a radical shift in the endorsement of the teaching profession, Arthur?

LEVINE: No. I don't know if a governor around the country these days isn't talking about economic development being tied entirely to education. STEM is at the center, but that hasn't resulted in dramatically different policies.

▶ **MICHELE LEZAMA** EXECUTIVE DIRECTOR, NATIONAL GEM CONSORTIUM: The reality in 2014 is that if I am a middle school parent and I want access to a top public school, I have to make sure that my child scores high on the entrance exam. Period. End of story.

Look at New York City's specialized schools. Their students are more than 60 percent Asian, 33 percent white, and 2 percent black and Latino, right? Yet the school district is 50 percent historically underrepresented groups. Those schools are filled by populations that invest in test preparation.

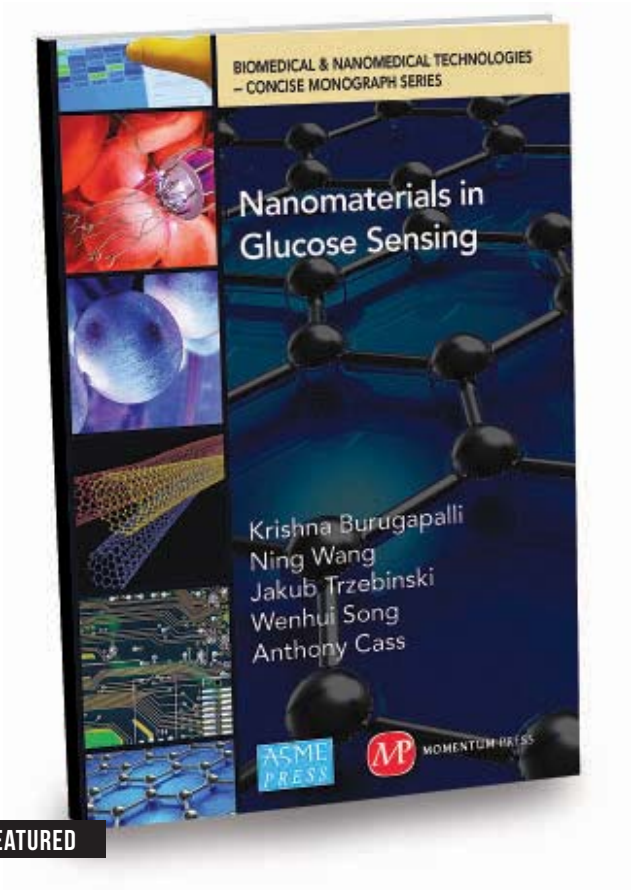
Ancillary programs that teach to the test are the way to gain access. This is happening around the country. And to get into a top university, my child needs a certain score on the ACT or SAT, right? They have to have at least a four or five on their AP just to have access to the level of rigor they need in order to be competitive and get a job.

▼ **IRENE NEEQUAYE** GRADUATE STUDENT, GEORGE WASHINGTON UNIVERSITY SCHOOL OF PUBLIC HEALTH AND HEALTH SERVICES: We should remember that teachers need support, too. You can start by paying teachers more and giving them better resources so they can take their classes on field trips and bring better gadgets into the school.

Another thing: The University of North Carolina at Chapel Hill has a program that prepares science students to go into education and be a good science teacher. You stay an extra year, but it is worth it. You are not just saying, "I am good at science, so I am going to do Teach for America and go into an inner city school even though I don't know how to be a teacher. And then I get in there and I get frustrated because the school system doesn't really care about science."

We need to really decide as a country that are we going to make STEM important. If we all decide that, we can definitely do it. ME

"WE NEED TO REALLY DECIDE AS A COUNTRY THAT ARE WE GOING TO MAKE STEM IMPORTANT. IF WE ALL DECIDE THAT, WE CAN DEFINITELY DO IT."



FEATURED

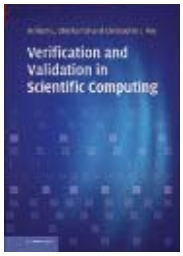
NANOMATERIALS IN GLUCOSE SENSING

KRISHNA BURUGAPALLI, NING WANG, JAKUB TRZEBINSKI, WENHUI SONG, AND ANTHONY CASS

ASME Press Books, Two Park Avenue, New York, NY 10016-5990. 2014.

Nanomaterials have the potential to be considered "smart" in biomedical applications due to their unique physicochemical properties; their use in glucose sensing has been aimed at improving performance, reducing cost, and miniaturizing the sensor and its associated instrumentation. As this volume, part of the Concise Monograph series, recounts, handheld glucose analyzers have been introduced for hospital wards, emergency rooms, and physicians' offices; and single-use strip systems achieved nanoliter sampling for painless and accurate home glucose monitoring; advanced continuous monitoring devices having two to seven days of operating life are in clinical and home use. Continued research efforts are being made to develop increasingly advanced glucose monitoring systems that employ nanoscale features for use in the biomedical, food processing, and allied industries.

68 PAGES. $89.95; ASME MEMBERS, $72; ISBN: 978-0-7918-6027-4.



VERIFICATION AND VALIDATION IN SCIENTIFIC COMPUTING

William L. Oberkampf and Christopher J. Roy
Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473. 2014.

Advanced scientific computing has made modeling and simulation an important part of the decision-making process in engineering, science, and public policy. Oberkampf and Roy provide a comprehensive and systematic account of the basic concepts, principles, and procedures for verification and validation of models and simulations. They place a particular emphasis on models that are described by partial differential and integral equations and on the simulations that result from their numerical solution. The methods described can be applied to a wide range of technical fields, such as the physical sciences, engineering, and technology, as well as to a wide range of applications in industry, environmental regulations, product and plant safety, and even financial investing. The authors intend the book to be used by researchers, practitioners, and decision-makers who seek to improve the credibility and reliability of simulations results. It may also be appropriate for university courses or independent study.

790 PAGES. $170.00. 978-0-5218-3758-3.

ENCYCLOPEDIA OF THERMAL STRESSES

Richard B. Hetnarski
Springer-Verlag GmbH, Tiergartenstrasse 17, 69121 Heidelberg, Germany. 2014.

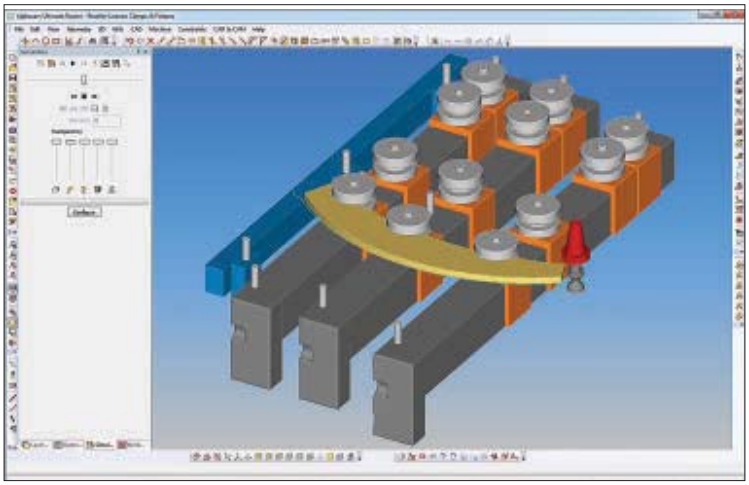
The *Encyclopedia of Thermal Stresses* is an interdisciplinary reference work with a particular emphasis on topics in the field of thermal stresses, but it also contains entries on related topics such elasticity and heat conduction. The book is intended for undergraduates, graduate students, researchers, and practicing engineers. Although Richard B. Hetnarski is listed as author, the encyclopedia articles were written by 614 experts in various topics residing in more than 60 countries; its creation took two and a half years. The publisher calls the *Encyclopedia of Thermal Stresses* the largest single publication devoted to the field of thermal stresses ever published. It contains 11 volumes comprising altogether 6,725 pages.

6,643 PAGES. $5,000. 978-9-4007-2738-0.

PARTS DRAWINGS FROM 2-D TO 3-D

VERO, CHELTENHAM, U.K.

THE LATEST RELEASE OF CAD AND CAM SOFTWARE from Alphacam includes enhancements to 5-axis toolpath functionality and the ability to automatically convert 2-D design data to 3-D. The toolpath optimizer allows users to optimize the toolpath to a specific machine configuration and rotational axis limits. Any changes to the toolpath data or machine configuration will be highlighted and the operation can be updated. The part modeler includes the ability to convert 2-D files into 3-D automatically. Enhancements include a redesign of the automatic feature extraction dialog with improved layout and images for each option.



Two-dimensional drawing files can be automatically converted into 3-D CAD models with the newly updated CAD and CAM Alphacam. The update includes several other new features. Image: Vero Software.

ANALYSIS WITHOUT THE MATH

GEOMATE CO., SAN JOSE, CALIF.

The ToleranceCalc application works directly with CAD geometry without the need to mathematically describe the problem, according to Geomate. The application acts as a bridge between design, quality, and manufacturing requirements for those without specialized knowledge of dimensional engineering or statistical tolerance analysis. It performs minimum and maximum, worst-case, Monte Carlo statistical, and sorted percent contribution analyses. It also performs one- and two-dimensional tolerance stack-up analysis at any stage of the design process.

CAD FOR CUTTING

ESAB WELDING AND CUTTING, FLORENCE, S.C.

Columbus III version 1.2 is a CAD and CAM programming and nesting software for plasma, oxy-fuel, laser, and waterjet cutting. This version includes a standard CAD shape library to aid in creating part programs. The upgrade enables parts to be imported from an existing assembly without the need for customized import filters, which allows for data exchange between the application and an enterprise resource planning system. It also improves remnant creation by automatically optimizing the remnant cut geometry on the existing layout to simplify remnant plate creation while maximizing material use. This cutting technology has been upgraded with three new bridge configurations. The patterns allow continuous cutting of external contours with a single pierce and provide better links for bridges than was available in past versions.

FEA IN THE CLOUD

SIEMENS PLM, PLANO, TEXAS.

NX Nastran is now available in a cloud environment via a software-as-a-service model. The solution integrates computing hardware with the finite element analysis software and is delivered through Rescale Inc., a cloud-simulation platform provider in San Francisco. Engineering companies and engineers can subscribe to the software, which is housed on the vendors' servers, and can use it to perform virtual product simulations. The platform allows engineers to run numerous instances of the FEA software, including large-scale simulations, to evaluate design options. Numerous workflow options are offered, including executing one job at a time, running multiple jobs in parallel, and performing designs of experiment simulations, which execute hundreds of individual runs for various design parameters.

ROBOTIC SIMULATIONS

ABB ROBOTICS, AUBURN HILLS, MICH.

Robot Studio Picking PowerPac identifies potential risks and optimizes cell design of robotic picking lines via 3-D simulations. It combines two of the company's software applications for the design and programming of robotic picking-and-packing systems, allowing systems to be optimized in a 3-D virtual world before being built. The software also allows for the improvement of existing lines configured using one of those two applications, PickMaster 3, by recording current product flow with cameras and then feeding the recordings into Robot Studio Picking PowerPac for validation and optimization.

VIEW ANALYSES AND GRAPHS

ORIGINLAB, NORTHAMPTON, MASS.

The standalone application Origin Viewer 9.1 allows viewing and copying of information from Origin Project Files without having Origin data analysis and graphing software installed. Users can now view rotatable OpenGL 3-D graphs, which can be distributed and used without installing the analysis and graphing software. The viewer allows users to collaborate by sharing project files with colleagues who do not have Origin. Multiple graphs can be viewed at the same time by opening them in resizable floating windows. Contents of the project file can also be copied into third-party software such as Microsoft Word or Microsoft PowerPoint for the creation of reports and presentations. **ME**

SUBMISSIONS

Submit hard copy or e-mail **memag@asme.org**, using subject line "Software Exchange." *ME* does not test or endorse software described here.

HAND-HELD LASER SCANNER

HEXAGON METROLOGY, NORTH KINGSTOWN, R.I.

The Leica T-Scan 5 has almost double the stand-off distance and is more than 15 times faster than the previous model, which results in more efficient data capture, especially in difficult-to-reach areas. It is suitable for non-contact laser scanning for CAD-to-part inspections and reverse engineering applications, and provides immediate feedback of critical features after design iterations. The scanner is typically used in applications within the aerospace, automotive, shipbuilding, and earth-moving industries.

MAGNETOSTRICTIVE SENSORS

MTS SYSTEMS CORP., CARY, N.C.

A new sensor is designed specifically for high temperature applications, including steam valves and steel mill machinery. Temposonics G-Series Model GTE embedded magnetostrictive sensor is specified to operate at temperatures as high as 85 °C and features a dual redundant output. This sensor also features an IECEx Zone 2 approval for use in hazardous areas.

PROXIMITY SENSOR

SICK USA, MINNEAPOLIS.

The CQ4 capacitive proximity sensor is used for detecting and monitoring a wide range of objects and materials. The CQ4 features a miniature IP 67-rated fiberglass housing that is ideal for industrial applications with limited space. The CQ4 has a high switching frequency up to 100 Hz and a sensing range of up to 8 mm, for high-speed object detection through non-metallic surfaces.

WELDABLE HINGES

J.W. WINCO INC., NEW BERLIN, WIS.

RoHS-compliant hinges are produced from drawn weldable profiled stainless steel or aluminum extrusions. The hinge pin is retained in the lower half. Offered materials include European Standard No. 1.4308 cast stainless steel (American Standard 304C15), European Standard No. 1.4401 A4 stainless steel (American Standard Series 316), or weldable aluminum 3.3206 (American Standard 6060). Sizes range from 60 to 180 mm in length (2.36 to 7.09 inches). Metric and inch sizes are interchangeable.

MARINE EMERGENCY GENSET

CUMMINS INC., CHARLESTON, S.C.

The QSK60 C power generator set features an optional air shut-off valve to meet the emergency shutdown requirements of offshore applications including drill ships. The 60-liter genset is available with certificates from all the major marine classification societies and is compliant with the latest EPA and IMO emissions regulations. The Genset has a Cummins marine auxiliary engine fit with radiator cooling and two independent starting systems.

CABLES FOR THERMOCOUPLES

OMEGA ENGINEERING INC., STAMFORD, CONN.

Omega's new exclusive M12CM series of M12 cables with compensated connectors for thermocouples feature a straight and right-angle M12 field-mountable connector sensor end, compensated thermocouple cable, sockets, and pins. Two cable insulation options are available in IEC and ANSI color codes. The M12CM series has a variety of connection methods to work with instrumentation. This product can be used where the operating temperature exceeds the limitations for standard M12 cables and sensors.

DENTAL 3-D PRINTERS

STRATASYS LTD., MINNEAPOLIS.

The Stratasys CrownWorx and FrameWorx 3-D printers allow dental laboratories to produce wax-ups for crowns, bridges, and denture frameworks. The printers use wax deposition modeling technology, which is designed to enable consistent quality and a reliable process. The machines produce wax-ups for crown, bridge, coping, and denture frameworks.

OILFIELD TRANSFORMER

GE DIGITAL ENERGY, MARKHAM, ONTARIO.

The new Prolec-GE multitap transformer is designed for onshore artificial lift operations. It will continue working through severe electrical distribution system disturbances, providing continuous, reliable operation. Equally important, it is designed to operate under a variety of extreme conditions found within the oil and gas industry, including high humidity, ultraviolet radiation, chemical pollution, and saline fog. The transformer powers the pump during artificial lift extraction methods to increase the flow of oil from a production well to the surface.

ULTRASONIC SENSORS

AUTOMATIONDIRECT, CUMMING, GA.

UK6 series 18 mm ultrasonic sensors are now available with shorter bodies for easier mounting in tight spaces. The new UT2F wide face series of 30 mm sensors has an increased sensing distance of up to six meters. Both series are available with 10 output types in combinations of PNP and NPN discrete outputs; 0-10 V dc or 4-20 mA analog outputs are available. These IP67-rated sensors are equipped with LED status indicators and have either an attached two-meter output cable or an M12 quick-disconnect connector.

TACHOMETER GENERATORS

MARSH BELLOFRAM CORP., NEWELL, W. VA.

Westcon 758-9910001 ac tachometer generators are designed to convert rotational shaft speed inputs into a linear analog voltage output, even in the harshest of environments. The tachometers feature a standard ¾-inch drive shaft, with only a 3.0 oz.-in. starting torque. Their components are housed within an explosion-proof case that is ATEX certified for Class 1, Division 1; Class 1, Group D; and Class 2, Groups F and G. Series units are also UL listed.

TOOLING FOR TITANIUM

KENNAMETAL INC., LATROBE, PA.

The company is offering its tools made of a new KCSM30 milling-grade metal, which it says can extend tool life by as much as 25 percent when working with titanium. With a fine-grained carbide substrate for strength and stability together with a TiAlN PVD coating for wear resistance, the tools permit cutting speeds, up to 230 sfm (70 m/min).

TRAPPED-KEY SAFETY SYSTEM

KIRK KEY INTERLOCK CO., MASSILLON, OHIO.

The trapped-key interlocking system ensures that workers follow a pre-determined sequence of operation for activating valves used in industrial settings from manufacturing plants to petrochemical facilities. Eagle Valve Interlocks attach to the valve body without voiding a manufacturer's warranty. The new bolt interlocking options integrate with Kirk's current standard-duty, medium-duty, and heavy-duty mechanical and electromechanical trapped key interlock series to form a comprehensive safety scheme.

PRECIPITATOR SYSTEM

BIONOMIC INDUSTRIES INC., MAHWAH, N.J.

The HEI wet electrostatic precipitator system incorporates discharge electrode technology that can be sized to specific applications, and concentrates a high intensity ionizing corona in strategic areas within the collecting tubes instead of distributing it along the entire length of the tubes' treatment area.

CLAMPING FORCE BLOCK

SCHUNK INTEC INC., MORRISVILLE, N.C.

A standardized clamping force block provides for flexible monitoring along the whole jaw stroke. Whether using ID or OD clamping, the positions "opened" or "clamped" for any base jaw position can be adjusted. Monitoring is done via two inductive proximity switches, which are integrated in two recesses in the base jaws. The system is sealed to resist dirt.

LED SCANNER

PEPPERL+FUCHS, TWINSBURG, OHIO.

The multi-beam LED scanner R2100 combines the manufacturer's exclusive pulse ranging technology with IR LEDs and multi-beam scan. The combination delivers two-dimensional measurement over an entire area rather than just one point to ensure precise and reliable distance measurement and detection of irregular surfaces. As a result, it can be used with indoor and outdoor mobile equipment, intralogistics, and machine and plant engineering applications where unique surfaces need to be accurately and reliably detected.

FLUID RECYCLING SYSTEM

ERIEZ, ERIE, PA.

The CRS fluid recycling system can recycle any water-miscible fluid to its maximum potential and in doing so minimizes or eliminates disposal, reduces usage of the fluid concentrate, and improves plant profitability and productivity. Systems range in size from small to large and feature low maintenance, unattended operation, and fast return on investment.

SUBMISSIONS

Submit electronic files of new products and images by e-mail to memag@asme.org. Use subject line "New Products."
ME does not test or endorse the products described here.

CONVEYOR OVEN

DAVRON TECHNOLOGIES INC., CHATTANOOGA, TENN.

The DTI-1220 is an electrically heated infrared indexing conveyor oven that preheats composite material blanks, prior to press forming. It was originally designed for a Tier 1 automotive supplier. Prior to commissioning the DTI-1220, customers preheated the product in a conveyor oven that did not allow it to run blanks of multiple sizes. The DTI-1220 indexing conveyor oven enables Davron's customer to process their largest part or two smaller parts in the same oven in as little as 45 seconds.

FUEL DISPENSER

PARKER HANNIFIN CORP., CLEVELAND.

The CNG dispenser was designed by Parker's Veriflo Division. Breakthrough features of the dispenser include: 4X burst pressure rating components; ball valves with a life of 100,000 full cycles; integrated system design resulting in 15-20 percent fewer leak paths. It also features certified components from Parker; ANSI NGV 4.1/CSA 12.5 compliant design; and ANSI/NGV 4.2/CSA 2.52 certified hoses.

FILAMENT FOR PRINTED BEARINGS

IGUS INC., EAST PROVIDENCE, R.I.

Igus has introduced a new plastic filament for 3-D printers that is enhanced with tribological, or low friction, properties. The material is 50 times more resistant to wear and abrasion than conventional 3-D printer materials and is suited for creating custom bearings. Igus has been researching filaments for 3-D printers in order to provide customers with more flexibility in their design ideas.

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If you are looking for information regarding an ASME code or standard committee, conformity assessment program, training program, staff contact, or schedule of meetings:

PLEASE VISIT OUR WEBSITE: WWW.ASME.ORG/CODES

COMMITTEE LISTING: For a listing of ASME Codes and Standards Development Committees and their charters, visit the Standards and Certification website at http://cstools.asme.org/charters.cfm.

CONFORMITY ASSESSMENT: For a listing and description of ASME Conformity Assessment (accreditation, registration, and certification) programs, visit the Standards and Certification website at http://www.asme.org/kb/standards/certification---accreditation.

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SCHEDULE OF MEETINGS: Meetings of Codes and Standards Development Committees are held periodically to consider the development of new standards and the maintenance of existing standards. To search for scheduled meetings of Codes and Standards Development Committees, by date or by keyword, visit the Standards and Certification website at http://calendar.asme.org/home. cfm?CategoryID=1.

PUBLIC REVIEW DRAFTS

An important element of ASME's accredited standards development procedures is the requirement that all proposed standards actions (new codes and standards, revisions to existing codes and standards, and reaffirmations of existing codes and standards) be made available for public review and comment. The proposed standards actions currently available for public review are announced on ASME's website, located at http://cstools.asme.org/csconnect/PublicReviewpage.cfm.

The website announcements will provide information on the scope of the proposed standards action, the price of a standard when being proposed for reaffirmation or withdrawal, the deadline for submittal of comments, and the ASME staff contact to whom any comments should be provided. Some proposed standards actions may be available directly from the website; hard copies of any proposed standards action (excluding BPV) may be obtained from:

MAYRA SANTIAGO, Secretary A
ASME Standards & Certification
Two Park Ave., M/S 6-2A
New York, NY 10016
e-mail: ansibox@asme.org

ASME maintains approximately 500 codes and standards. A general categorization of the subject matter addressed by ASME codes and standards is as follows:

Authorized Inspections
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Certification and Accreditation
Chains
Controls
Conveyors
Cranes and Hoists
Cutting, Hand, and Machine Tools
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Elevators and Escalators
Energy Assessment
Fasteners
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Gauges/Gaging
Geometric Dimensioning & Tolerancing (GD&T)
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Keys and Keyseats
Limits & Fits
Materials
Measurement of Fluid Flow in Closed Conduits
Metal Products Sizes
Metric System
Metrology and Calibration of Instruments
Nondestructive Evaluation/ Examination-Nuclear
Operator Qualification and Certification
Performance Test Codes
Piping & Pipelines
Plumbing Materials and Equipment
Post Construction of Pressure Equipment
and Piping
Powered Platforms
Pressure Vessels
Pumps
Rail Transportation
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Corrosion
Resistant Equipment
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Screw Threads
Steel Stacks
Surface Quality
Turbines
Valves, Fittings, Flanges, Gaskets
Verification & Validation
Welding & Brazing

The ASME Standards & Certification section is published as submitted to Mechanical Engineering magazine by ASME's Standards & Certification Department.

Perkinson Chair in Experimental Mechanics
School of Aerospace and Mechanical Engineering
College of Engineering at the University of Oklahoma

The College of Engineering at the University of Oklahoma seeks to establish leadership in the strategic, high-impact research areas such as advanced materials and energy-related topics during the next five years. Accordingly, the School of Aerospace and Mechanical Engineering is seeking outstanding candidates to fill the Perkinson Chair as an Associate Professor or Professor, with tenure as appropriate.

We seek candidates with a demonstrated expertise and research leadership in the broad area of experimental mechanics. Some example domains include:

- Enabling techniques in micro and nanosystems, including sensing, actuation, and control of such systems at multiple length scales
- Thermomechanical, optical, and other imaging techniques for characterization of behavior of materials and structures
- Experimental techniques to probe and determine the condition of systems and components used in aerospace and energy industries

Candidates for the Perkinson Chair shall possess an earned doctorate in mechanical engineering, aerospace engineering, or a related field. The candidates are expected to have an outstanding publication record coupled with a strong record of funded research.

The School of Aerospace and Mechanical Engineering currently has 21 full-time faculty members, and over 700 undergraduate and 70 graduate students. Candidates can learn more about the School of Aerospace and Mechanical Engineering from its website (http://www.ame.ou.edu).

Candidates are invited to submit a statement of vision for this opportunity, a statement of research interests and plans, a curriculum vita, and a list of five references. Screening of candidates will begin August 1, 2014, and continue until the position is filled. Candidates are requested to submit their applications electronically in one PDF file to:

Perkinson Search Committee Chair
School of Aerospace and Mechanical Engineering
University of Oklahoma, Norman, Oklahoma 73019
e-mail: amefacultysearch@ou.edu

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POSITIONSOPEN

ASSISTANT PROFESSOR IN MECHANICAL ENGINEERING POSITION DESCRIPTION The Department of Mechanical Engineering at the University of Louisville is searching for an Assistant Professor in Mechanical Engineering (non tenure-track). Candidates must have expertise in the formulation and use of numerical simulations for metal additive manufacturing processes. The successful candidate must be prepared to establish a research program, teach graduate and undergraduate courses and mentor graduate students and post-doctoral scholars in the area of additive manufacturing simulations. MINIMUM QUALIFICATIONS: The successful candidate must have: An earned Ph.D. in Mechanical Engineering or a closely related field; an ability to secure extramural research funding; an ability to teach graduate-level coursework in the area of additive manufacturing simulations; an ability to teach undergraduate coursework in Mechanical Engineering; broad experience with the derivation and implementation of multi-physics, multi-scale deformation theories and approaches, including crystal plasticity finite element methods and a knowledge of beam theories; an ability to solve thermo-mechanical problems involving moving energy sources for both melting and solid-state additive manufacturing techniques; experience with temporal and spatial homogenization; evidence of the above-mentioned expertise via publications in peer-reviewed journals and/or conferences. LOCATION: University of Louisville, The Department of Mechanical Engineering, Sackett Hall, Louisville, KY 40292. HOW TO APPLY: Applicants should submit a letter of application that indicates their qualifications, a current curriculum vitae, and a short description of their future teaching and research plans online, at **https://highereddecisions.com/uofl/current_vacancies.asp**.Job ID# UL173. The expected starting date is August 2014. EEO/AA Policy. The University of Louisville is an Affirmative Action, Equal Opportunity, Americans with disabilities Employer, committed to diversity, and in that spirit, seeks applications from a broad variety of candidates.

NANJING TECH UNIVERSITY FACULTY POSITIONS in College of Mechanical and Power Engineering. This announcement invites applications for tenure-track faculty positions in: Mechanical Engineering, New Energy Science and Engineering, Welding Technology and Engineering, Mechanical Design Manufacturing and Automation, Vehicle Engineering, Process Equipment and Control Engineering. Required Qualifications: Ph.D. in Mechanical Engineering or a closely related field is required. Initial appointments are at the assistant professor level. Exceptionally qualified candidates at the associate or full professor level may also be considered. Rank and salary are commensurate with experience and accomplishments. Candidates should send application to chunleishao@njtech.edu.cn. A CV, list of publications, statements of research and teaching plans are required. Applications received before December 31, 2015 will be guaranteed full consideration. For more information about the position, please visit **http://www.njtech.edu.cn**.

UPSTART TAKES TOP HONORS AT

THE ASME HUMAN POWERED VEHICLE CHALLENGE East witnessed a dramatic turn of events when the University of Central Florida swept the competition, securing the overall top spot and unseating perennial favorites Rose-Hulman Institute of Technology and the Missouri University of Science & Technology.

Thirty-two teams of ASME student members competed at the April event in men's and women's drag races, an endurance test, and evaluations based on design and innovation.

Mechanical problems were rife at 2014's HPVC. Over the course of the three-day event, entries from Rose-Hulman of Terre Haute, Ind., and Missouri S&T of Rolla experienced fateful mishaps that relegated the long-time rivals to second and fifth places. The University of Central Florida's team blazed through events held at its Orlando campus. *Knightrike*, its entry, earned the top spot in every category except design, where it came in second.

The HPVC East-winning team from Central Florida stands behind Knightrike, *their human-powered vehicle that can race at speeds of up to 42 mph. .*

Visit Facebook for more about the HPVC program: **https://www.facebook.com/ASMEHPVC**

Rose-Hulman's entry, *Namazu*, tipped over during the first HPVC East event, the women's speed competition, finishing 24th. The team, which won the design category and was the runner-up in the innovation category, never fully recovered over the next two days, finishing fifth in the men's drag race and eighth in the endurance event.

Cheryl, Franklin W. Olin College's entry placed third. *Cheryl* malfunctioned during the endurance event, but with her teammates running and cheering alongside, the team's driver pushed her vehicle the remainder of the course and over the finish line to claim a third-place finish in

ENERGY AND MANUFACTURING POLICY DISCUSSED

ASME President Madiha El Mehelmy Kotb, NIST director Patrick Gallagher, and ASME President-Elect J. Robert Sims at a ceremony at the Department of Commerce. Kotb and Sims presented the ASME President's Award to Gallagher at the event.

MEMBERS OF CONGRESS AND THE Obama administration discussed their strategies to encourage a resurgence in the U.S. manufacturing sector and the challenges and opportunities facing the energy industry during a daylong symposium in Washington, D.C.

The annual Engineering Public Policy Symposium brought together leaders from 43 national engineering societies representing more than two million engineers. ASME served as the chair and lead organizer of the April event, which was made possible by a grant from the United Engineering Foundation.

Tom Kalil, deputy director for technology and innovation at the White House Office of Science and Technology Policy, served as the event's keynote speaker. Kalil discussed the administration's strong emphasis on investing in technology innovation and R&D, and in promoting a "maker culture" in the U.S.

Kalil asked the engineering community for support for the National Network for Manufacturing Innovation and for assistance in promoting manufacturing events around the country—such as the upcoming White House Maker Faire—that celebrate engineering and science participation.

Later, **Daniel Poneman**, Deputy Secretary of Energy, highlighted some of the Department of Energy's priority initiatives, including the president's Climate Action Plan. Poneman said

HPVC EAST

the race. The Olin students received the event's "Team Spirit" award for their efforts.

The HPVC West event, held in San Jose, Calif., a few weeks later, had more predictable results. Rose-Hulman took top honors as the overall winner of the event after placing first in the design and innovation categories.

Placing second and third overall were the teams representing Northern Arizona University in Flagstaff and Missouri S&T, respectively.

Twenty-six teams participated at HPVC West, which was hosted by the ASME Santa Clara Valley Section and Santa Clara University.

In an impressive reversal of fortunes, the University of California, Berkeley team bounced back from a mechanical breakdown during the sprint races to take first place at the endurance event the following day. To correct the mechanical problems, the Berkeley students stayed up all night to make repairs to their vehicle.

HPVC East and West followed the inaugural HPVC India competition on this year's human-powered vehicle competition schedule. A fourth competition, HPVC Latin America, is slated for Mexico City in October. **ME**

AT SYMPOSIUM

severe weather events such as Hurricane Sandy serve as a reminder of the vulnerability of the U.S. electric grid and the key role that engineers must play in developing strategies for adapting to and mitigating the effects of both natural and man-made threats to critical infrastructure.

Representative **Chris Collins** of New York, one of a handful of engineers in Congress, spoke about his efforts to bring engineering perspectives to public policy, and Congressmen **Tom Reed** and **Tim Ryan** were honored for their leadership in manufacturing policy as co-chairs of the House Manufacturing Caucus and their work in advancing manufacturing in Congress.

ASME President **Madiha El Mehelmy Kotb** presented an award on behalf of the symposium's co-sponsoring organizations to **Patrick Gallagher**, director of the National Institute of Standards and Technology, in recognition of his work in promoting industrial innovation and competitiveness.

After the symposium, participants met with their representatives in the House and Senate to discuss engineering and science budget priorities. Many urged sustained federal funding in support of energy issues, R&D, and the NNMI.

The next day, Kotb presented NIST's Patrick Gallagher a second award. He received the second one, the ASME President's Award, during a meeting at the Department of Commerce. Established in 1998, the ASME President's Award is presented to individuals and companies who have demonstrated significant contributions to the engineering profession. **ME**

Sandra Kolvick, John Blanton, and John Lammas at the redesignation ceremony in Greenville, S.C.

REDESIGNATED LANDMARK: BELLE ISLE TURBINE

THE BELLE ISLE TURBINE—THE FIRST GAS turbine to be used for electric utility power generation in the U.S.—was redesignated as an ASME Historic Mechanical Engineering Landmark in a ceremony held at the GE Power and Water headquarters on April 26 in Greenville, S.C.

In July 1949, General Electric delivered the turbine to the Belle Isle Station of the Oklahoma Gas and Electric Co. It originally received landmark status in 1984; its 2013 relocation to a new home in South Carolina prompted the Greenville Section's History and Heritage chair, **John Blanton**, to nominate the turbine for redesignation.

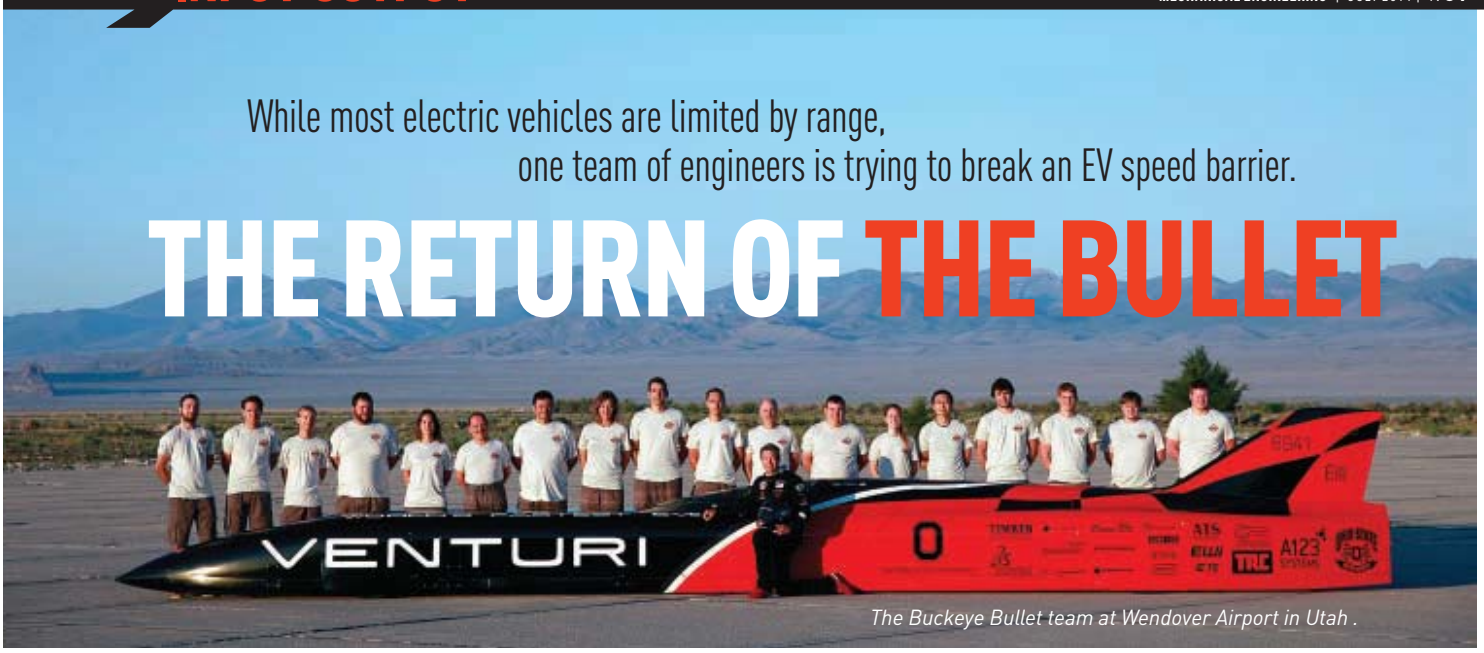
ASME landmark status recognizes the machinery's pioneering role in the power generation industry in the U.S. According to its landmark plaque, the turbine, which GE began developing prior to World War II, "represents the transformation of the early aircraft gas turbine, in which the engines seldom ran more than 10 hours at a stretch, into a life-long prime mover."

Also at the ceremony were **Sandra Kolvick**, chair of the ASME Greenville Section; **John Lammas**, vice president of power gen engineering at GE Power and Water; members of the Greenville section, and personnel from the GE Power and Water plant. ■

Tom Kalil of the White House Office of Science and Technology Policy talked about promoting a "maker culture."

While most electric vehicles are limited by range, one team of engineers is trying to break an EV speed barrier.

THE RETURN OF THE BULLET



The Buckeye Bullet team at Wendover Airport in Utah .

THE STUDENT TEAM AT OHIO STATE UNIVERSITY HAS A HISTORY WITH SPEED. It built the world's fastest heavy electric car, the Venturi *Buckeye Bullet 2.5*, which set an international record of just over 307 mph on the Bonneville Salt Flats in 2010. Before that, the team built the world's fastest hydrogen fuel cell car, the *Buckeye Bullet 2* in 2009, but the car's top speed of 303 mph was a disappointment.

The students are now hoping to break 400 mph with their latest electric vehicle, the Venturi *Buckeye Bullet 3*.

"The number of wheel-driven vehicles that have gone 400, regardless of power type, is only about 10," said David Cooke, the graduate student who leads the Buckeye Bullet team.

"In the past we have been fast for students, or fast for electric. We are now working to be fast period."

Since 2010, Cooke's team of four to five core students (and another ten to twenty volunteers) has been working on the car at the Center for Automotive Research at Ohio State. Their advisor, Giorgio Rizzoni, holds the Ford Motor Company Chair in electromechanical systems at Ohio State and is director of the center.

The team expects to do plenty of testing and tuning before the *Buckeye Bullet 3* achieves its speed goal. Come this August, it will be driven by Roger Schroer, a professional driver who works at the Transportation Research Center, an automobile proving ground, outside of Marysville, Ohio.

Back in the lab, students assemble one of four electric motors.

The vehicle has eight separate battery packs, four motors and motor controllers, eight cooling loops, and several vehicle level controllers. Its wheels are not powered directly with wheel motors, but by a gearbox, with two reduction speeds, that is powered by two motors. A ring and pinion transmit power to half shafts that go to the wheels. The layout is similar to that of a conventional front-wheel-drive vehicle, but it is duplicated for the front and rear wheels, with no connection between the front and rear drivelines, except the road.

The students collaborated with Hewland Engineering Ltd. of the U.K. to design the car's custom gearbox. According to Cooke, "It is a one-off custom case designed for our team's needs and to integrate with our suspension. It also has a second input shaft that is used with our aircraft brakes so that they can move the brakes in-board for packaging reasons."

The aircraft brakes for the *Buckeye Bullet 3* are based on a type used on regional jets. The team designed custom housings, shafts, torque plates, and calipers.

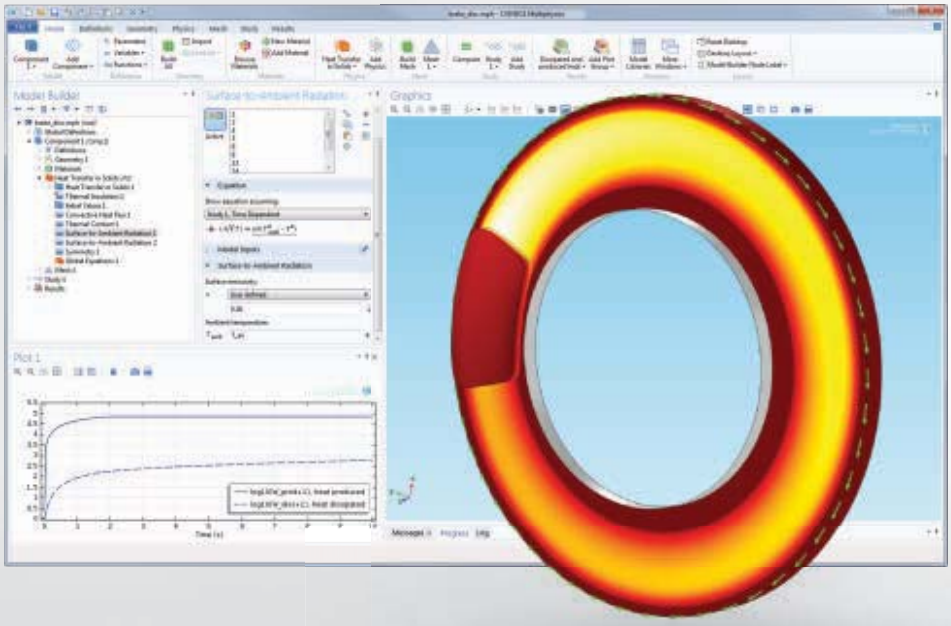
The program is expensive. Cooke estimates that if this were a three-year design, build, and race program, the cost in cash without sponsored parts, would probably be $5 million, and that would not include the building and resources used at OSU.

Venturi Automobiles, a maker of high-end electric vehicles based in Monaco, is the major program partner and is responsible for a great deal of the Venturi *Buckeye Bullet 3*'s operating expenses. Venturi also worked with the students to develop the car's drive-train technology.

They have professional help but it is still a student effort. "The team works constantly on the vehicle, with members putting in 5 to 80 hours a week of work," Cooke said. "Once school is out for summer, it's 100-hour weeks for the months leading up to racing in Bonneville. It's an extremely talented and dedicated group." ME

JAMES PERO

HEAT GENERATION AND DISSIPATION: Results from a simulation of a disk brake show the temperature evolution and distribution during the braking and release stages.



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