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Livermore ends LIFE

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ARPA–E, a success by some measures, remains fragile

As the Advanced Research Projects Agency–Energy celebrates its fifth birthday next month, it boasts a portfolio of 362 clean-energy projects. Backed by more than $900 million in grants, those projects span 18 technology areas that range from developing innovative renewable energy sources to exploring alternatives to rare-earth metals and microorganisms for the reduction of vehicle emissions. Twenty-two of the awardees, who were recipients of ARPA–E grants totaling $95 million, have attracted a total of $625 million in private financing. In addition, at least two dozen project teams sponsored by ARPA–E have spawned new companies to commercialize their technologies.

Although those numbers may seem impressive, ARPA–E's future, let alone growth, isn't altogether assured given the austere budget climate. The House of Representatives had passed a bill last year that would have slashed ARPA–E's fiscal year 2014 budget to $50 million, an 81% reduction from the $265 million provided in FY 2013. Although the final appropriation for this year was set at $280 million after negotiations with the Senate, the experience demonstrates how the 42-person office, part of the Department of Energy, is "still fragile" and just one appropriation away from becoming largely irrelevant, said Bart Gordon, the former Tennessee Democratic representative who helped to codify ARPA–E in the America COMPETES Act. That law, which authorized a variety of new science education and technology development programs at multiple agencies, expired in October 2013, and reauthorization efforts have stalled. President Obama has included $325 million for ARPA–E in his fiscal year 2015 budget request.

Gordon was among program supporters who spoke at the annual ARPA–E conference outside Washington, DC, in late February. Representative Paul Tonko (D-NY) said the ARPA–E budget "pales in comparison to what it should be." And Senator Chris Coons (D-DE) agreed that Congress "should accelerate its investment significantly." Cheryl Martin, acting ARPA–E director, said that the agency could ramp up to a $1 billion budget over time, though certainly not within one year. "We see more problems and ideas than we [can] fund. Over time, those kinds of numbers are appropriate," she said.

For an operation that was created to back high-risk, high-payoff technologies, ARPA–E has had few failures so far. Of the 362 projects funded to date, only 18 have been terminated, Martin says. Many others have altered their objectives though, she adds.

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that requires half the amount of vanadium as currently available versions. That would represent considerable savings, since vanadium electrolyte costs about $200/kWh. The company anticipates additional performance enhancement with a low-cost ion-exchange membrane, which is based on a renewable biopolymer. Thomas Kodenkandath, ITN program manager, says that 500 cycles have been demonstrated to date; ARPA–E's requirement is 1000. The company is aiming for residential and small-scale applications and for a cost of $1000 per unit. Using other battery technologies, such units now sell for around $4000.

Other flow batteries include one being developed by Harvard University (shown in the photo on page 25).

Duracell technology

Not all the technologies backed by ARPA–E are flow batteries. The City University of New York, working with a $3.5 million grant, is advancing a rechargeable zinc–manganese oxide cell, the same chemistry used in disposable alkaline batteries. CUNY's original award was extended for a year to support efforts to reduce dendrite formation and extend the life of the anode, says Jerome Fineman of CUNY's Energy Institute. The battery has achieved 3000 cycles to date, but he says the institute is aiming to push that number to 5000. Meanwhile, a CUNY spinoff, Urban Electric Power, has licensed and begun marketing the Zn–MnO_2 battery and a separate zinc–nickel battery developed without ARPA–E funding, for homes with uninterruptible power needs and for home backup power systems in India and other less developed nations. Last year, the company opened a $6.1 million, 5000-$m^2$ R&D and manufacturing facility in New York's Harlem district, funded in part by state and local agencies.

According to Ann Marie Scuderi, business development manager, the Zn–MnO_2 technology could attain the $100/kWh cost target once production is scaled up.

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Livermore ends LIFE

Lawrence Livermore National Laboratory has quietly shelved a program that was developing a design for a plant that generates electricity from laser fusion. The Laser Inertial Fusion Energy (LIFE) program was meant to provide a practical application of fusion energy following the attainment of ignition at the lab's National Ignition Facility (NIF). But achieving ignition—characterized by the release of energy in excess of that required to initiate the fusion reaction—is more than a year behind schedule.

Despite achieving a significant milestone at NIF last September (see the Politics and Policy report on the PHYSICS TODAY website), LLNL remains far from ignition. Last fall's experiment, published earlier this year, produced fusion energy equal to about 1% of the laser's 1.8-mJ input.

"The focus of our inertial confinement fusion efforts is on understanding ignition on NIF rather than on the LIFE concept," LLNL acting director Bret Knapp said in a statement. "Until more progress is made on ignition we will direct our efforts on resolving the remaining fundamental scientific challenges to achieving fusion ignition." He added that the lab will continue to support and invest resources in underlying science and in technology projects, such as materials research, diode lasers, and fuel targets, that could enable fusion as an energy source. A LIFE plant would implode 1.3 million precisely manufactured fuel capsules each day.

The mothballing of the program will result in no job losses, Knapp said.

Some fusion researchers have criticized LLNL for having seriously understated the challenges to be overcome in order to build an inertial confinement fusion (ICF) power plant. Indeed, an article in the July/August 2011 issue of LLNL's *Science & Technology Review* had stated that a demonstration power plant generating 400 megawatts could be operational by the mid 2020s.

"In my opinion, the overpromising and overselling of LIFE did a disservice to Lawrence Livermore Laboratory," says Robert McCrory, director of Rochester University's Laboratory for Laser Energetics, a laser fusion lab funded by the Department of Energy. Construction of the ICF facility would have to start today, he notes, given the lack of manufacturing capacity for the laser glass that would be needed. Even with none of the powerhandling systems that LIFE would need, NIF took 13 years to build.

Mike Dunne, who had headed LIFE, says that he will continue to manage a wide range of R&D projects addressing key technical risks in the development of inertial fusion energy. Topping the list of needs is a new type of laser—likely diode—that's capable of firing more than a dozen times each second. NIF's glass laser is capable of firing only one or two "shots" per day.

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news notes

Graduate demographics in the US. How many women are earning advanced physics degrees? How many people are from underrepresented groups? How long is it taking people to earn their degrees? The makeup of US exiting-master's and PhD recipients over time, with an in-depth look at the classes of 2010, 2011, and 2012, are the subjects of two recent reports by the Statistical Research Center at the American Institute of Physics. An exiting master's is someone who leaves his or her physics department after earning a master's degree—including those who continue studies in physics elsewhere or switch to another field.

In 2012 a new high of 1762 PhDs were awarded in physics. That number is up 4% from the previous year and 62% from a recent low in 2004. The median number of physics PhDs awarded by departments went from four to six in that period. On average, PhD recipients in the classes of 2010 and 2011 took 6.3 years to earn their degrees.

The average age of PhD recipients was 30.5 for the combined classes of 2010 and 2011; for the exiting master's recipients, it was 28.9. For both degrees, 10% of recipients were 35 or older.

For the years 2010–12, women made up 19% of PhD recipients and 23% of exiting-master's recipients. At both the PhD and master's levels, Hispanic Americans and African Americans continue to be underrepresented, although in less than 10 years the number of Hispanic Americans earning PhDs has shot up by 300%.

More details are available in the reports, *Trends in Physics PhDs* and *Trends in Exiting Physics Master's*, which can be downloaded at http://www.aip.org/statistics/graduate. **TF** ■

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