

Potentially transformative

The NCI's supercomputing infrastructure is dwarfed by DOE's, Kibbe says. Rather than trying to duplicate the kind of computing resources that DOE has, the NCI wants to "help inform the next generation of supercomputers at the national labs so they are appropriate for biomedical research." Currently the NCI has access to computers that can either handle large amounts of data or focus on computation. What it needs today are machines that do both, Kibbe says.

The collaboration, which Kusnezov says must be mutually beneficial to work, will be "potentially transformative" for DOE. "We see an opportunity to put machine-learning chips and big-data analytic chips together with the [central processing unit], and have them work together," he says. "Traditionally when we've designed the next-generation architectures, it's been toward a more traditional view of high-performance computing: solving partial differential equations, evolving things in time, doing some large Monte Carlo [simulations]."

The NCI's wealth of data could help DOE address the challenge of validating some of the tools that are developed for the new computing architectures across many length scales, says Kusnezov. "We run a simulation and compare it to data. But we don't do it dynamically. The question is, If we had machine learning that was tuned to dynamic streams of data, could we run it in parallel in our large simulations to try to dynamically validate our codes across length scales in real time?"

David Kramer

Billionaires join governments to fight climate change

Public and private initiatives aim to bring innovative clean energy technologies to market.

As representatives from 195 nations descended on Paris in December and concluded a landmark agreement to curb climate change, government leaders and billionaires from around the world announced separate initiatives to accelerate the development and deployment of new clean energy technologies. The heads of 20 nations pledged to double their countries' funding for energy R&D over five years, and 27 billionaires, including Virgin Group founder Richard Branson, Alibaba chairman Jack Ma, and Amazon CEO Jeff Bezos, joined forces to form the Breakthrough Energy Coalition and promised to invest their resources to commercialize fledgling energy technologies.

No dollar amount was specified for the public or private efforts, but the countries' pledges reportedly would increase R&D spending by \$8 billion annually over five years, with \$4 billion of that to come from the US. In a November interview in the *Atlantic*, Microsoft founder Bill Gates, who organized the Breakthrough Energy Coalition, said he has committed \$2 billion of his fortune to clean energy R&D. The University of California, the sole institution to join in the billionaires' pledge, committed \$1 billion over five years to the coalition.

Although the amount promised by the other billionaires is unspecified,



though wind and solar energy use have increased dramatically with the help of subsidies, “there hasn’t been an increase in the core R&D that drives the next generation of technologies,” he says. “How are we going to power airplanes? Not with batteries. How will we get fuels if not from biofuels? How can we make nuclear power a more serious option?”

Bending the curve

Matthew Bunn, a professor with Harvard’s Belfer Center for Science and International Affairs, a technology and policy think tank, says the billionaires will likely invest in commercially riskier technologies than they normally favor. But if the ventures succeed, they would still expect to receive a substantial sum. “It’s sort of philanthropic investment instead of giving money away,” he says.

The priority, says Bunn, is for cleaner, cheaper technologies to be deployed at the scale needed to really “bend the curve on greenhouse gas emissions. That scale is huge,” says Bunn. He points to a highly cited 2004 estimate by Robert Socolow and Stephen Pacala at Princeton University, who calculated that keeping the global temperature rise since preindustrial times at or below 2 °C in 2050 would require curtailing carbon emissions by 7 billion tons annually. Today the United Nations Environment Programme estimates that amount to be 18 billion tons. Emissions have grown faster than had been expected, and inaction over the past 11 years has shortened the time available to achieve stabilization. Earth’s atmosphere currently contains about 800 billion tons of carbon as carbon dioxide.

The governments that have signed on to the Mission Innovation doubling pledge are Australia, Brazil, Canada, Chile, China, Denmark, France, Germany, India, Indonesia, Italy, Japan, Mexico, Norway, South Korea, Saudi Arabia, Sweden, the UK, the United Arab Emirates, and the US. Their commitment “is an important signal of how important this is,” says Bunn. But, he adds, “I have grave doubts as to whether we are going to get \$4 billion worth of increased energy R&D spending out of the US Congress.”

Todd Stern, the US special envoy for climate change, acknowledged that there are already plenty of clean energy alternatives and more opportunities for their

deployment. “But that’s not enough to lick this problem; we still need transformational discoveries and inventions,” he told the Center for American Progress on 15 December. “That happens by doing really serious basic research and having investors ready to help get discoveries over the various death valleys from discovery to commercialization.” Stern credited Indian prime minister Narendra Modi with leading the Mission Innovation initiative.

In a joint statement, the government leaders who signed the pledge said they “will build and improve technology innovation roadmaps and other tools to help in our innovation efforts, to understand where research and development is already happening, and to identify gaps and opportunities for new kinds of innovation. Participating countries may also pursue joint research efforts through public-private partnerships as well as joint research among participating countries.” The first meeting to plan implementation of the initiative is to be held early this year.

In their pledge, the billionaires have agreed to follow several common principles in making their investments. They will provide funding through a variety of early-stage channels, including seed, angel, and Series A (preferred stock). And they will invest