DIETER TELEMANS/PANOS

that is already arising from population growth. The modellers found that climate-driven changes in evaporation, precipitation and run-off will result in a 40% increase in the number of people worldwide who must make do with less than 500 cubic metres of water per year — a commonly used threshold to signify 'absolute' water scarcity.

The spread between individual models was large — some suggested that global exposure to water scarcity will double; others predicted only modest change. But no matter what the spread, the greatest effects were seen between the present-day climate and a 2 °C warmer world.

Despite the ambiguities, the exercise will make climate-risk analysis substantially more robust, says Johan Rockström, an expert on water resources at the University of Stockholm and director of the Stockholm Resilience Centre, who was not involved in the project.

"Impact models will never be able to provide the level of detail that ultimately matters for making a city or coastline climate-proof," he says. "But they do serve as a first approximation to the severe problems deficient regions and nations are facing."

Regions most at risk from water scarcity include parts of the southern United States, the Mediterranean and the Middle East. By contrast, India, tropical Africa and high latitudes in the Northern Hemisphere can expect to receive more water in a warming world.

The projected changes in water availability have knock-on effects in other areas that rely on water. The group that modelled the response of crops to climate change found negative impacts on yields of major crops in many agricultural regions[2].

In addition, drought conditions are likely to become more frequent and severe in some parts of South America, western and central Europe, central Africa and Australia, another project team reports[3]. Flood risk is less clear-cut, but river-flow simulations from global hydrology and land-surface models did show an increase in flood hazard in more than half of the world[4].

Water scarcity in parts of Africa could become worse, according to a complementary set of climate projections.

Despite their uncertainty, the findings are "a stark reminder" that even moderate warming has the potential to cause severe natural, social and economic disruptions, says Rockström. "We are facing problems that result in domestic instability and migration." Rethinking international trade with a view to giving the most needy nations better access to the global food market will be essential, he says.

Uncertainty, adds Schellnhuber, is no excuse for inaction. "Those who might say, 'Come back when you've narrowed down the risk' should be reminded that climate change is a treacherous gamble," he says. "We don't quite know the odds, but the chance of losing heavily might be a lot bigger than many tend to think." ■

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2. Rosenzweig, C. *et al. Proc. Natl Acad. Sci. USA* http://dx.doi.org/10.1073/pnas.1222463110 (2013).
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PHYSICS

X-ray source left without home

No plans to build next-generation accelerator despite large investment by US agency.

BY EUGENIE SAMUEL REICH

Accelerator physicists have a vision: an energy-efficient X-ray source that can make high-resolution movies of molecules in chemical reactions. And the US National Science Foundation (NSF) has backed the dream — since 2005, it has invested more than US$50 million to develop such a source, most likely beneath the campus of Cornell University in Ithaca, New York.

But there is one big problem: despite the inflow of cash, no US government agency has any plans to build the machine.

The source, called an energy recovery linear accelerator (ERL), would be a hybrid of a synchrotron, in which electrons emit X-rays while whirling around a ring, and a free-electron laser, in which straight beams of electrons are induced to produce bright pulses of X-ray light.

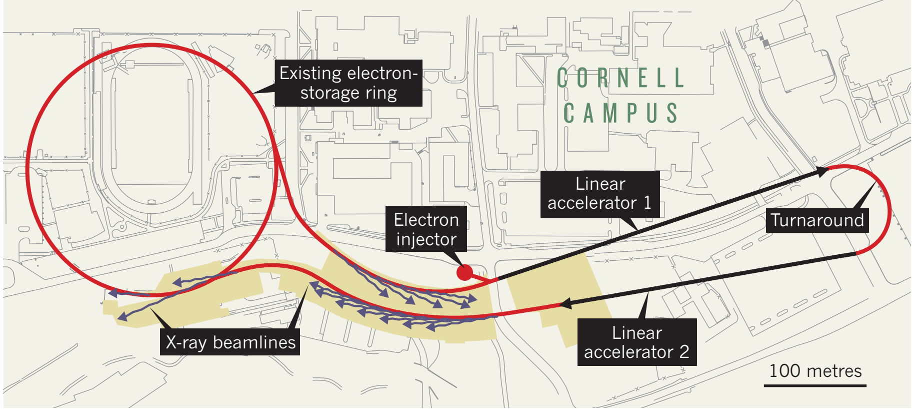
The Cornell project is currently receiving $27 million in a single award from the NSF's materials division — by far the division's largest grant for instrument development. But in July, the ERL concept was ranked the lowest of three potential next-generation X-ray sources by an advisory panel to the US Department of Energy. And in December, officials at the NSF told *Nature* that the agency has no plans to move forward with construction.

Despite all this, Thomas Rieker, the NSF programme manager for the ERL materials grant, says that the research effort has been a success, providing component designs that would allow an accelerator to be built quickly. "We wanted to keep our options open," he says. "That was the impetus for funding it."

An NSF advisory panel had strongly recommended in 2008 that the NSF invest in an ERL. So why the turnaround? Agency officials now say that the NSF's priorities and the budgetary climate have changed, and that a machine costing upwards of $1 billion would not be a good use of taxpayers' money. ▶

ELECTRONS IN RECOVERY

Cornell University in Ithaca, New York, wants to convert an existing synchrotron into an energy recovery linear accelerator, but it is unlikely that either the US National Science Foundation or the Department of Energy will build it.



SOURCE: CORNELL UNIV.

Some physicists are expressing frustration over seeing so much research money apparently going nowhere. "The NSF should really decide if there's a real need for this in the country," says Sunil Sinha, a condensed-matter physicist at the University of California, San Diego, who advised on the energy-department panel.

The idea for an ERL was developed in 1965 by Cornell physicist Maury Tigner. It involves injecting electrons into a linear accelerator (linac) and then wiggling the particles to prompt the emission of X-ray pulses. The energy-recovery aspect comes from a loop that ushers the electrons gently around to enter the linac a second time. Their arrival is timed so that their energy is transferred to a new bunch of electrons that will then be accelerated.

The approach has several advantages. For starters, it would be vastly more energy-efficient than a free-electron laser, which recovers no energy. That makes it practical to keep electrons streaming continuously, rather than in widely separated bunches. An ERL can also focus its electron beam, and hence the resulting X-rays, to a tighter spot than the beams in current synchrotron rings, which spread out as they lose energy going around in circles. This would allow for more-advanced studies of the atomic energy levels in materials.

> ***"The NSF should really decide if there's a real need for this."***

Japan and the United Kingdom have both expressed interest in building an ERL, and there is a small demonstration version of an infrared ERL at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. But Cornell's plan is the most advanced X-ray ERL effort in the United States.

Grant documents stress that the ERL research is not site-specific, meaning that it could feed into projects elsewhere. But most experts think that, if an ERL gets built, it would be at Cornell, where it could reuse the tunnels of an existing NSF-funded X-ray light source, the Cornell High Energy Synchrotron Source (see 'Electrons in recovery'). "We feel the construction of an ERL can go right ahead," says Georg Hoffstaetter, an accelerator physicist who is leading the Cornell effort.

The capabilities of an ERL would overlap with those of other planned light sources. In California, the Department of Energy has plans to build a free-electron laser, perhaps by upgrading the Linac Coherent Light Source at the SLAC National Accelerator Laboratory in Menlo Park, California. This machine would provide images of materials with unprecedented resolution in space and time, using fast pulses of high-energy X-ray beams.

Pulses of X-ray light from an ERL would not be as fast, but they would be gentler, and nearly continuous — more appropriate for probing sensitive samples such as biological specimens. However, next-generation ring-shaped light sources, such as an upgrade planned at the Advanced Photon Source near Chicago, Illinois, will also stream continuous light. Although less bright and lower in energy than an ERL, such sources would still prove useful for biological imaging.

The energy department's decision to go with the other machines will make it harder for the ERL to justify itself scientifically, says Paul Evans, a materials scientist at the University of Wisconsin–Madison. "Defining the niche they're headed for is the critical challenge."

Even if the ERL is not built, Cornell scientists say that the research has been useful. Their work is aiding design of superconducting cavities for the Deparment of Energy's future free-electron laser, which could also one day have energy-recovery loops tacked on. Cornell has also developed a high-current electron gun that could be used in other accelerators to generate X-rays or to study particle collisions.

But although he takes satisfaction in the spin-off possibilities, Hoffstaetter is not ready to give up on the ERL's construction. "The ERL is a wise investment," he says. ■