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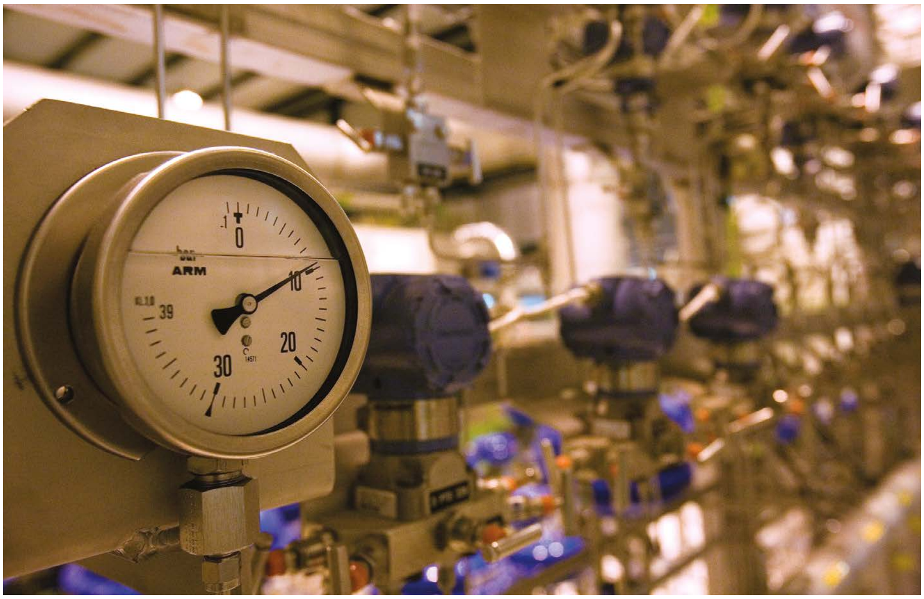

Cryogenics account for more than half of the LHC's electricity consumption.

ENERGY CRISIS SQUEEZES SCIENCE AT CERN AND OTHER MAJOR FACILITIES

Large Hadron Collider to end 2022 data-taking season two weeks early to save on electricity.

By Brian Owens

As energy prices spike as a result of Russia's invasion of Ukraine, possibly causing a global economic downturn and stoking fears of rolling blackouts — especially in Europe — science laboratories are not being spared. The situation has raised particular alarm at CERN, Europe's particle-physics lab outside Geneva, Switzerland, which already has massive energy bills in normal years.

On 26 September, CERN's governing council agreed to significantly reduce the facility's energy consumption in 2022 and 2023, after Électricité de France (EDF), a French electricity supplier, asked the lab to decrease the load on its network. The council decided to bring forward the lab's annual year-end technical stop by two weeks, to 28 November, and to reduce operations by 20% in 2023 — which will be accomplished mostly by shutting down four weeks early next year, in mid-November. Operations will resume as planned at the end of February, in both 2023 and 2024.

CERN has also developed plans with EDF for reduced power configurations, in case energy use needs to be limited further in the coming months. Smaller measures are being taken to reduce overall energy use on the CERN campus, including switching off street lighting at night and delaying the start of building heating by one week.

Keeping cool

CERN's flagship machine, the 27-kilometre-long Large Hadron Collider, is a major electricity glutton, in large part because of its 27-megawatt liquid-helium cryogenic system, the largest of its kind in the world. During normal operations, the annual electricity consumption of CERN is about 1.3 terawatt-hours (for comparison, nearby Geneva uses around 3 terawatt-hours per year). Yearly maintenance periods for the LHC are scheduled during the winter months, to save on its bills. Consumption falls to about 0.5 terawatt-hours during longer shutdowns, as happened in 2020–22. After extensive upgrades, the LHC restarted in April, and the total electricity cost is expected to be about 88.5 million Swiss Francs (US$89 million), says Joachim Mnich, director for research and computing at CERN. The reduction in operations will lower that significantly next year, although not by the full 20%, because the accelerator magnets still need to be kept cool while the facility is offline.

"We are doing everything we can to make sure our 3,000 users are not left out to dry."

The move will help to save money amid rising energy prices, but Mnich says cost was not the main driver of the decision. Natural gas is the primary source of electricity and heating in the winter in much of Europe, and CERN wants to reduce its use of the limited supplies, leaving more for people to heat their homes. "This is something we do not primarily to save money, but as a sign of social responsibility," he says.

The longer shutdowns will affect the scientists who rely on CERN's other accelerators for their experiments. Those that were scheduled for the last two weeks of this year's run will have to be postponed until next year, and the competition for the reduced beam time next year will be fiercer than usual, says Mnich. The total number of proton–proton collisions in the LHC will be lower than normal this year and next, but Mnich does not expect that to have a huge effect on the science. "On the scale of the whole of run 3, which goes until the end of 2025, there will probably only be a small effect," he says.

Energy prices are also rising significantly in the United Kingdom, although institutions there would not say how this will affect their operations in the short term. A spokesperson for Imperial College London says that, although the university, like all large organizations, is affected by the rising cost of energy, "we are confident in our resilience and ability to respond to the challenge". The Science and Technology Facilities Council, which runs several large sites, including the Diamond Light Source in Didcot, says all of its facilities "have been working on energy-reduction plans for a number of years to meet their net-zero commitment and reduce cost".

Tightening belts

The German Electron Synchrotron (DESY) in Hamburg is also affected by higher prices. The facility buys much of its electricity in tranches up to three years in advance, to hedge against sudden price spikes. So it has already procured 80% of its energy needs for 2023, 60% for 2024 and 40% for 2025. But the lab will need to make a decision soon on whether to buy the remaining 20% for next year, says Wim Leemans, director of the accelerator division. "At current prices we are not able to afford it," he says.

DESY is in talks with the German government to seek extra funding to maintain operations, which are making important scientific contributions to areas that are essential to the future of Europe, such as the development of COVID-19 vaccines, battery technology and solar power, Leemans points out. But its managers are also preparing for the worst.

Next week, they will run tests to see how running instruments such as the European X-ray Free-Electron Laser and PETRA III synchrotron at lower power settings would affect experiments. And as a last resort, DESY is considering a longer winter break, like CERN is. "We are doing everything we can to make sure our 3,000 users are not left out to dry," says Leemans.

Research facilities in other parts of the world are also dealing with rising energy costs. Bill Matiko, chief operating officer of the Canadian Light Source (CLS) in Saskatoon, says electricity costs make up a "significant" part of the lab's annual budget, at around 8%. Although Canada's domestic energy production, especially of natural gas, means the situation there is not as dire as in Europe, prices are still on the rise owing to high inflation – electricity rates went up by 4% on 1 September, and will go up again by another 4% by 1 April next year. About half of that increase had been anticipated and budgeted for, says Matiko. "It's something we can somewhat easily accommodate by moving things around in the budget," he says.

The CLS, like many big, energy-intensive facilities, has been working to improve its energy efficiency over the past several years, says Matiko. For example, all lights at the facility were replaced with LED bulbs, and cryo modules were switched to new superconducting cooling devices that are much more energy efficient. "Those have significant savings in terms of power consumption," he says. "The energy bills are a fraction of what they would be otherwise."

Labs in North America, such as CLS, will not need to reduce operating time, but they probably will not be able to accommodate European scientists who are losing beam time. CLS is already oversubscribed, says Matiko. With the Advanced Photon Source (APS) at Argonne National Laboratory in Chicago, Illinois, shutting down in April 2023 for an upgrade that will take at least 12 months, beam time in North America is about to be constrained as well. "Already, some APS users want access to our beams," says Matiko. "There's going to be a big increase in demand for us and for others."

CHINA'S FIRST SOLAR OBSERVATORY TO PROBE MYSTERIOUS ERUPTIONS

The mission will also help to improve forecasts of damaging space weather.

By Elizabeth Gibney

China launched its first dedicated solar observatory on 9 October. Astronomers say its trio of instruments will provide insights into how the Sun's magnetic field creates coronal mass ejections and other eruptions.

The Advanced Space-based Solar Observatory (ASO-S) lifted off from the Jiuquan Satellite Launch Center in northern China. China has sent satellites with individual Sun-gazing instruments into space before, but the 900 million yuan (US$126 million) ASO-S is its first observatory with a suite of tools.

Scientists in China have been waiting a long time for the observatory. They first pitched such a mission in the 1970s, says Weiqun Gan, an astrophysicist at the Purple Mountain Observatory of the Chinese Academy of Sciences in Nanjing, and the mission's chief scientist. "We always wanted to do something like this," he says.

Astronomers know that the Sun's magnetic field causes its energetic emissions, but unravelling the relationship between the two is notoriously complex. ASO-S will be important for understanding these connections because its instruments look across different wavelengths at once, says Eduard Kontar, an astrophysicist at the University of Glasgow, UK, and a member of the mission's science committee. Studying different aspects of the Sun's activity simultaneously allows researchers to tie eruptions to their underlying causes.

"These are very exciting times for solar physicists in China and around the world."

ASO-S joins a slew of solar missions already in orbit around Earth or the Sun. "These are very exciting times for solar physicists in China and around the world," says Kontar.

Four-year mission

ASO-S – also known by the nickname Kuafu-1, after a giant in Chinese mythology who sought to catch and tame the Sun – will observe from an orbit 720 kilometres above Earth's surface, permanently facing the Sun.

The mission will last for at least 4 years, says Gan, covering the 2024–25 peak of the solar cycle, which lasts 11 years on average. "In these peak years we can observe a lot of eruptions," he says.

The Sun produces high-energy bursts of radiation, known as solar flares, and coronal mass ejections (CMEs), slower streams of particles released in explosions. ASO-S's main task will be to study the fundamental physics of these eruptions and their origins in energy released by the Sun's contorting and realigning magnetic field. The process is one of "great scientific importance, with broad implications for understanding similar phenomena throughout the Universe", says Kontar.

Solar flares and CMEs can affect Earth when they reach and interact with the planet's atmosphere. The resulting 'space weather' has the potential to interfere with navigation systems and disrupt power grids. ASO-S can help with forecasting space weather by providing data about the shape of magnetic fields on the Sun's surface that are most likely to cause eruptions – knowledge that could allow researchers to predict when and where such eruptions will happen, says Gan.

The observatory's three instruments include a magnetograph to study the Sun's magnetic field and an X-ray imager for studying the high-energy radiation released by electrons accelerated in solar flares. ASO-S also carries a coronagraph, which will peer at the Sun in the ultraviolet and visible range, from the solar surface through to the Sun's outer atmosphere, or corona, to scrutinize the plasma produced by flares and CMEs.

A unique feature of ASO-S will be its ability to study an important region known as the middle corona – where solar storms brew – which has never been seen in its entirety in the ultraviolet spectrum, says Sarah Gibson, a solar physicist at the US National Center for Atmospheric Research in Boulder, Colorado. This will give new clues to the origins of CMEs, she says.

Following the probe's initial four-to-six-month commissioning phase, ASO-S data will be open for anyone to access, and Chinese solar physicists are eager to collaborate, says Jean-Claude Vial, an astrophysicist at Paris-Saclay University.

Data from ASO-S could complement those from other solar observatories. The European Space Agency's Solar Orbiter, which launched in 2020 and flies close enough to the Sun to sample its atmosphere, carries a coronagraph similar to that on ASO-S. From their different vantage points, the two instruments will produce complementary observations, says Gibson. NASA's Parker Solar Probe, launched in 2018, also flies close to the Sun to sample its atmosphere.