D. SIMONDS

Experimenting with efficiency

In 1971, no one really worried about energy efficiency — certainly not at Fermilab, the US Department of Energy's (DoE's) particle-physics laboratory in Batavia, Illinois. A new superconducting ring for the lab's accelerator, designed to push particles closer than ever to the speed of light, was enthusiastically talked up as the 'energy doubler'. A few years on, though, as the lab prepared its funding bid against the backdrop of the oil crisis, the system started being referred to as the 'energy saver', shifting the emphasis from increased performance to reduced power requirements.

When you spend US$1 million a month on electricity, as Fermilab does, such care in presentation is important. Under most circumstances, though, scientists give scant thought to totalling up the wasted power and unnecessary carbon emissions that their work generates. Geoffrey Bell, who works on reducing the energy consumption of Lawrence Berkeley National Laboratory in California, is one of the exceptions. He's eager to point out that a traditional fume cupboard, for example, uses as much energy in a year as three US households. "If you have a laboratory with 50 of those, you've made a town in one building!"

Laboratories consume between five and ten times more energy than office buildings — but they are also rarer and more diverse in design, making neat, generalized solutions to profligacy hard to find. Add that to concerns about safety and a lack of transparency in costs (few scientists know or care what their lab's electricity bill is), and you get a 'that's just the way they are' mentality. That's the mindset that the Labs21 programme, an initiative started by the DoE and the US Environmental Protection Agency (EPA), exists to challenge.

According to the EPA's Dan Amon, who oversees Labs21, the big beast for energy experts to tame is ventilation: some 60–70% of the energy a lab uses goes on moving, heating and cooling the air, with the rest split about two to one between appliances and lighting. Labs21 concentrates its efforts on 'wet labs' — chemical or biological labs fitted with fume cupboards, which need to exchange the lab's air with outside air at a high rate. Bell, a member of Labs21, says that most of these facilities have been designed according to "what is in the drawer", with fume cupboards making many more air changes, and at higher velocities, than is necessary. In the United States and Britain, safety standards require that air is exchanged 6 to 12 times an hour. Yet rates as high as 15 to 25 per hour are not unusual. Even a small reduction from 12 to 10 air changes per hour can reduce the amount of fan power by more than 40%, says Bell.

> **"The more modern the laboratory, the worse its energy consumption."**
> — Peter James

A key to progress here is replacing fume cupboards that replace air constantly with technology that has a variable air volume. A variable-air-volume fume cupboard adjusts the speed of the fan, and therefore the energy use, to the position of the cupboard's sash opening. As the requirements for ventilation change — when researchers open and close the sashes — the building's exhaust and supply fans adjust accordingly. Bell says that some US labs have used a carrot-and-stick approach to encourage careless researchers to make the most of this technology by using the sashes on their cupboards sensibly. "Beware the sash police," he jokes, "they might make you walk around with your apron on backwards as a punishment."

The new Science and Technology facility at the DoE's National Renewable Energy Laboratory (NREL), completed in July last year, is designed on Labs21 principles, with an airflow rate of at least 0.3 cubic metres per minute per square metre (see 'Look, no carbon!'). With

ceiling heights of three to four metres, this means about six air changes an hour. In addition to variable-air-volume technology, the lab has systems to reuse the heat from exhaust air and from the water used to cool the equipment. It also makes extensive use of natural light and groups activities that require high ventilation rates together so they can be dealt with differently from the rest of the space. "Overall, if you were to compare this facility with a more conventional lab, the savings are about 41% of the overall energy cost," estimates NREL's Pete Sheldon, who coordinated the lab's design. "This is about $96,000 per year." He adds that it's the quality of the light that the researchers comment on most frequently.

Sustainable inklings

According to Phil Wirdzek, who had Amon's job at the EPA in the early 1990s, the Labs21 programme started more or less by accident. When reporting their annual energy consumptions to the US Congress, the EPA and the DoE went beyond what was required and included the energy bills of their various facilities in calculations. Wirdzek was responsible for his agency's report. "It was like, 'holy mackerel did I get us into trouble!' But it started Labs21 because we began to say: well, how do you fix these things?"

Now administered in part by Wirdzek's not-for-profit organization the International Institute for Sustainable Laboratories, Labs21 runs an annual conference and trade show, offers design assistance and training to labs, which become 'partners', and has recruited 4,000 engineers, architects and manufacturers to its green agenda. Designing an energy-efficient lab requires a different way of thinking, according to Amon. "If you don't tie into the community [of people thinking differently], then you are going to do what you have always done," he says. Bell emphasizes that when designing or refitting a lab, the key is to get all concerned — lab managers, contractors, scientists, union representatives, cleaning staff — to buy into the process from the beginning, and to ask why things are the way they are. Why are there so many fume cupboards and refrigerators? Why is the temperature tolerance so tight? Why are air-flow rates not reduced at night?

Although he doesn't put it all down to Labs21, Amon guesses that about a quarter of the labs in the United States now use energy-efficient design principles. Thanks to interest from the US Green Building Council in Washington DC, labs will soon be eligible for the prestigious Leadership in Energy and Environmental Design (LEED) awards that are already in place for office buildings, schools and shops.

Peter James, a professor in environmental management at Bradford University in the United Kingdom and coordinator of a public-sector initiative to raise universities' environmental performance, is importing the Labs21 approach to Britain. According to James, who took part in an analysis of data from around 50 campuses in Britain a few years ago, "a really horrifying thing we found was that, by and large, the more modern the laboratory, the worse its energy consumption". He points to more stringent health and safety requirements in the past ten years and to the wasteful margins being built into ventilation rates; like Bell and Amon, he is eager to assure people that the waste can be cut without compromising safety.

Two-way systems

Mike Dockery, a UK-based consultant who designs laboratory systems, argues that Britain can teach the United States a thing or two — specifically on 'FlexiLab' methodology. First developed by the drug giant GlaxoSmithKline for its UK facilities, the FlexiLab system is now being rolled out at the company's sites in the United States. Portable variable-air-volume fume cupboards connect into prefabricated, standardized ducting and service 'spines'. It makes it possible to change the type of science a lab is doing over the weekend, says Dockery, adding that reusability also means less wasted equipment when the lab's function changes. James says that in Britain, public labs are playing a game of catch-up with private companies.

But are scientists really ready to embrace sustainability in their own backyards? A recent online survey by the UK Department for Environment, Food and Rural Affairs had telling results. Of 400 scientists across a wide range of disciplines questioned in August 2006, 95% agreed that science and technology were important if sustainable solutions were to be developed for the future, but only 40% said that they always or often considered the effect their work would have on the environment when planning their research. Of those who didn't think about the environmental impact of their research, 53% said it was because they felt it wasn't relevant to their area of science.

The results don't surprise Bell. "Scientists tend to be in their own little world most of the time. They are not necessarily belligerent or disrespectful, they are just very focused people…and they really don't understand how they might be knocking things over in the process." "But," he adds, "at some point in time you have to pull them out of that blinders-on attitude to say, 'Look — you did great science over here and you made this new wizard medicine — but look what you did over here.'" ■

Zoë Corbyn is a freelance science writer based in London.

This week, Geoffrey Bell will be answering questions about this subject on the *Nature* newsblog (http://tinyurl.com/3a3d4f), where you can tell us what your lab is — or isn't — doing about energy efficiency.

Look, no carbon!

Two US labs have gone further than just using efficient energy, and have become 'carbon neutral'. The National Renewable Energy Laboratory (NREL) in Golden, Colorado (see right), and the Robert Kerr Environmental Research Centre in Ada, Oklahoma, think that they are the only labs in the world to have reduced and offset their carbon emissions to zero — blazing a trail for others to follow.

NREL, which researches everything from photovoltaics to biomass energy, has just completed its first carbon-neutral year by balancing its power use and emissions generated from staff flying to conferences and commuting to work with various energy-saving initiatives and offsets.

The lab uses ethanol-fuelled vehicles and has designed or refitted its buildings to Labs21 principles (see main story). It also uses energy generated from its experiments to power the facility, although this accounts for only about 5% of the lab's needs. "If we can capture power — like on our wind experimental site — then we will use it," says Robert Westby, who oversees sustainability at the facility. But the experiments are experiments first, practical generators second.

P. CORKERY/NREL/DOE

Burning tree thinnings from the nearby forest, NREL should be able to generate as much as 20% of its own energy this year, Westby estimates, thanks to a plant being paid for, designed, installed and operated by a private company. "The private sector sees that it can make money doing this," explains Westby, "so the lab doesn't have to make the investment."

The Robert Kerr lab, which does mostly groundwater research, decided to go 'zero emission' in April 2005. Like NREL, the lab supplements energy-efficiency measures and renewable-energy sources with the purchase of green-energy certificates — though travel is not offset. The 1960s lab has replaced its former natural-gas use with a 'ground-source heat pump'. A series of wells (also run as a public–private partnership) tap into the ground's constant temperature, cooling the lab in summer and warming it in winter. A variable air-volume system also reduces the amount of air and electricity required. **Z.C.**