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Adding efficiency to general lab equipment

Sometimes the latest equipment in a laboratory, say a next-generation sequencer, grabs lots of attention, but it’s the workhorses—centrifuges, hoods, freezers, incubators, and more—that keep experiments and workflows moving. These general lab tools often determine how smoothly and cost effectively a lab runs.

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Adding efficiency to general lab equipment

Sometimes the latest equipment in a laboratory, say a next-generation sequencer, grabs lots of attention, but it’s the workhorses—centrifuges, hoods, freezers, incubators, and more—that keep experiments and workflows moving. These general lab tools often determine how smoothly and cost effectively a lab runs. In large part, the results can be measured in one word—efficiency. In this case, efficiency means saving energy and time. **By Mike May**

General equipment makes up a lab’s foundation. Without these crucial tools, few experiments could be performed, because nearly every research project depends on one or more of such technologies. As fundamental elements of research, general lab equipment must also be efficient. “Energy efficiency in laboratory equipment is extremely important,” says John Dillott, energy manager at the University of California, San Diego. “It’s a major, yet virtually untapped area.” He mentions that My Green Lab, a California-based nonprofit, published a 2015 report estimating that there are more than 1.2 billion square feet of laboratory space in the United States. “These spaces are three to five times more energy intensive than office areas due to energy-intensive equipment, around-the-clock operations, 100 percent outside-air requirements, and high airflow rates,” Dillott says. “Not only does laboratory equipment consume a substantial amount of energy, but anyone who has ever been in a lab knows that the heat generated by lab equipment can lead to overcompensation by heating, ventilation, and air-conditioning systems, resulting in an additional increase in energy consumption.”

By saving energy, it takes less capital to run a piece of equipment, and some of the most basic equipment consumes a lot of electricity. According to the website of the International Institute for Sustainable Laboratories (I2SL) in Arlington, Virginia: “The energy used by [plug-in] equipment (e.g., freezers, autoclaves, centrifuges) constitutes from 10 to as much as 50 percent of the total energy use in a laboratory (not including associated cooling energy use).” I2SL’s web page adds, “Many scientists, laboratory managers, and laboratory design consultants are beginning to use energy efficiency as a selection criterion for laboratory equipment, and some manufacturers are starting to advertise the ‘green features’ of their products.” In an effort to start a central database of energy-efficiency information, I2SL created the Energy-Efficient Laboratory Equipment Wiki (http://scim.ag/EELERWiki).

When considering any technology upgrade for energy efficiency, scientists wonder about the payback: How long will it take to recoup the price of the new equipment through energy savings? “Payback is a difficult question to answer as it’s dependent on the initial purchase price, the cost of energy, how the equipment is used, and the type of equipment that is being replaced,” says Allison Paradise, executive director of My Green Lab. “In addition, so few studies have been done on energy consumption of laboratory equipment that it’s often difficult to know, without metering, what the baseline energy consumption is of the existing equipment and what the energy consumption is of the new equipment.” She adds, “Our nonprofit cofounded the Center for Energy Efficient Laboratories (CEEL) to address this specific need”—gathering real-world data on the energy used by general lab equipment. Only with those data in hand can scientists choose the most efficient devices.

Go with less flow

Of all of a lab’s general equipment, fume hoods probably carry the most energy-inefficient reputation, and with good reason—at least for older equipment. “Market Assessment of Energy Efficiency Opportunities in Laboratories,” prepared by Paradise, indicates that fume hoods consume far more energy than other standard pieces of equipment, more than twice as much as a −80°C freezer (when considering the highest end of the energy-consumption range for both hood and freezer), which is the second-highest energy consumer among a lab’s general equipment. Other sources agree on the energy intensity of fume hoods. As noted by Harvard University’s Green Labs Program: “Fume hoods are one of the most energy-intensive types of equipment in a laboratory environment, but significant savings can be achieved by keeping them closed when not in use.” That advice works for a fume hood of any age.

Making a fume hood more energy efficient depends largely on how air flows through it. One solution is provided by Labconco in Kansas City, Missouri, whose three-speed blower on its fume hoods offers flow-rate options. “This came from market demand—people wanted to turn down the blower at night, like a night setback mode,” says
Beth Mankameyer, sales engineer at Labconco and certified as a Leadership in Energy and Environmental Design (LEED) Green Associate by the U.S. Green Building Council. “They wanted their hood to exhaust less volume while it was unoccupied at night.”

The motor in a fume hood blower also matters. For example, Labconco’s three-speed blower uses an electronically commutated motor, which is more energy efficient than a traditional alternating current (AC) motor.

The electronics that control a fume hood also play a part in its energy efficiency. At TSI in Shoreview, Minnesota, saving energy in a fume hood comes from a sophisticated controller. According to the company website, its fume-hood controller adjusts the flow velocity for containment and safety, but it also “reduces laboratory airflow usage, optimizing energy savings.”

When it comes to a return on investment, a fume hood might make the best bet. “The three-speed blower can pay for itself in a very short amount of time,” says Mankameyer, “not only because of reduced energy costs at the hood but because less air needs to be conditioned for the lab.” The actual time of the payback depends on many factors, including the lab’s heating, ventilation, and air conditioning system, and how much a fume hood gets used, among others. But no matter what, a more energy-efficient fume-hood system will save on operational costs.

Air movement also matters in incubators, where the air’s composition comes into play. To keep an incubator effectively doing its job, the technology must include an easy way to decontaminate the device. In some incubators, that requires half a day of high heat. Instead, using a vapor hydrogen-peroxide method takes only four hours, says Kara Held, science director at The Baker Company in Sanford, Maine. That saves energy and time. So, as incubators reveal, the energy savings is not only about ordinary running, but also relates to the overall energy use for all operations of the technology.

For both hoods and incubators, modern versions provide forms of efficiency beyond saving energy. The three-speed fan can be set to automatically slow down during off hours, and some controls can do the same. That way, the lab manager can be sure of getting the best efficiency—in saving money and time. In addition, modern incubators, says Held, do a better job of controlling the conditions for cells. “You can find the optimal conditions, and they will stay there and not be affected by the external environment or room where the incubator is located.”

That’s because of improved sensors that control more features, such as temperature, humidity, oxygen, and carbon dioxide. To ensure your cells experience the optimal conditions as much as possible, explains Held, be sure to check how long it takes an incubator to reestablish the internal conditions after opening the doors. If it takes 20 to 30 minutes, be aware that other incubators can do it faster—often in half that time.

Keep it cool
Many items in a lab, from reagents to cell lines, need to be kept cool, even frozen—sometimes deeply frozen. All freezers are big consumers of energy, some more than others. “Generally speaking, ultra-low temperature freezers, –80°C, are some of the largest consumers of energy in life science research labs,” Dilliott says. “Individually, each freezer can consume as much energy as a single-family home, 20 to 25 kilowatt hours per day.”

As a general rule of thumb, Dilliott says, “It is worth noting that any piece of equipment that requires an operating set temperature or pressure and is kept on 24/7 is likely to consume a lot of energy.”

For lab-freezer shoppers, a new one can be much more efficient, but that’s not always the case. “It depends on the freezer,” Dilliott says. “Several models have been designed with energy efficiency in mind . . . often consuming 60 percent less energy than freezers using older technology.”

He adds, “These numbers are supported by the long-term metering data collected at the University of California, San Diego and at other organizations across the country.”

Depending on the lab in question, upgrading a freezer could be even more efficient than expected. For example, Dilliott says, “The savings realized by UC San Diego’s replacement of old freezers with more energy-efficient ones resulted not only in an operational cost reduction for the university, but also in additional rebates from the utility company.”

Some vendors do focus on overall energy efficiency in freezers. Santanu Das from technical product support at VWR International in Radnor, Pennsylvania, says, “VWR General-Purpose Upright Freezers, which maintain –20 or –30°C, are available with manual or automatic defrost and are designed to provide dependable, energy-efficient performance.” He adds that they are manufactured with chlorofluorocarbon (CFC)-free high-density urethane. cont.>
### Featured Participants

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foam cabinet and door insulation to maintain temperature stability. Those features help to reduce the energy required by any freezer.

In Cambridge, Massachusetts, Harvard’s Green Labs Program goes beyond the freezer technology and reveals energy-saving tips in using freezers. For example, this program recommends keeping your freezer organized so that you know where to look when you open the door and will thus open it less and for less time. As the program’s website states: “By limiting door openings you will save energy and increase the life of your freezer.”

VWR freezers can also be easier to organize and access. In describing VWR’s ultra-low temperature freezers, Das says, “Four gasketed inner doors are standard, creating four compartments that can be subdivided with adjustable interior shelves.” That design allows for better organization and easier location of items, which should lead to less time with the door open.

To help vendors design better freezers in the future, the CEEL is collecting energy-use data on existing ~80°C freezers. Scientists can help by taking part in a 10-minute survey ([https://www.surveymonkey.com/r/CEEL_ULTFreezers](https://www.surveymonkey.com/r/CEEL_ULTFreezers)). “All responses will remain completely confidential,” Paradise says. “You will not be contacted by any vendors as a result of your participation.”

Other changes can make your existing freezer use less energy. With a ~80°C freezer, Paradise says, “Changing the set point to ~70°C can save 20 to 30 percent, depending on the age of the freezer and its baseline energy consumption, according to the U.S. Department of Energy.” She adds, “My Green Lab has a saying that ‘~70 is the new ~80,’ and we like to encourage people to chill up their freezers.”

### Simpler spinning

For some general laboratory equipment, the main improvement in efficiency comes from ease of use. That is the case with centrifuges.

“A centrifuge is a fundamental piece of separation equipment,” says Hugh Tansey, worldwide product director at Thermo Fisher Scientific, headquartered in Waltham, Massachusetts, “and scientists want it to be easy to use and be more productive.” Today’s centrifuges allow scientists to easily change the rotor to spin down mixtures in microtubes, microplates, cell-culture containers, and so on.

In some cases, efficiency comes from being sure that a centrifuge does what you need it to do. For example, Daniela Dockweiler, senior application specialist at IKA Works in Staufen, Germany, says, “Today’s centrifuges provide constant speed while the rotor is attached on the drive shaft, even if there is a higher density of a liquid.” She adds that this consistency provides “reproducible results for all samples in one experiment.”

Some advances in centrifuges, like carbon-fiber rotors, also improve energy efficiency. “These are lightweight, corrosion-resistant, and durable, and enable much higher performance,” says Tansey. “This rotor can spin up and down faster, so the centrifuge uses less energy.”

### Keep it organized

In almost any lab, the list of general equipment gets pretty long. That makes it complicated to figure out the best way to keep a lab efficient. Held once worked as the lab manager for a facility with 24 incubators. To keep everything organized, she recommends, “Build little zones into the lab, so that the equipment for one task is in the same area.” Also, she suggests building a spreadsheet that includes all of the lab’s equipment. That lets you keep track of what you have in the lab, as well as when it was purchased and serviced.

Staying organized also helps a lab manager decide when something should be replaced. When asked about how to make that decision for a piece of general lab equipment, Held says, “It depends on the lab’s funding and what the equipment is being used for.” She adds, “For very general equipment, you usually wait until it breaks and the cost of fixing it is close to the cost of buying a new one.”

To keep a lab working as efficiently as possible, though, it’s worth thinking about replacing general equipment earlier in some cases. For example, a new hood might soon save a lab more than it costs. Likewise, a new freezer might be easier to keep organized than an old one. In the end, the most efficient lab—in terms of energy and time—gets the most done.

Mike May is a publishing consultant for science and technology.

DOI: 10.1126/science.opms.p1600104
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