small STEPS BIG RESULTS: GREENING THE MAGNET LAB

BY AMY MAST

The Magnet Lab is known for doing things big. Big-name scientists use big grants to do big research on some of the world's biggest magnets.

Some things, however, are better small — like trash piles, electric bills and water usage. From small steps such as recycling to hugely ambitious ones such as rethinking the design of research magnets, the lab is working to get the same big scientific results with a smaller environmental footprint. Many of the lab's conservation measures share the added advantage of saving money — another important goal in a research environment where every dollar matters.

Motion sensors replaced traditional light switches in many spaces throughout the lab.

Small steps, electrifying results

The world's most powerful magnets naturally require a lot of, well, power. The lab's superstar 45-tesla hybrid magnet, when running at full field, uses about $27,000 worth of power during a nine-hour work day. The overall power bill at the Tallahassee facility generally runs around $570,000 per month — about 7 percent of Tallahassee's total power capacity. Over the past three years the annual bill has been reduced by about $400,000 a year through a combination of simple measures that, when applied to a facility this size, can really add up.

During this time, the lab:

- Replaced an aging and inefficient vacuum pump with a lower-horsepower, more efficient pump. The old pump cost about $20,000 per year to operate; the new one, a mere $700.
- Replaced old air compressors with higher efficiency models, saving about $20,000 in electricity per year.
- Pulled out extra light bulbs in rooms that were already adequately lit.
- Installed motion sensors on the lighting systems in all offices so that they'll go dark when unoccupied.

Engineering technician Alfie Brown holds one of the lab's new induction lights, installed high over the Ion Cyclotron Resonance lab. Because the lights themselves have tiny magnetic fields of their own, they can only be used in labs with very high ceilings. *Photo by Amy Mast*

➤ Lowered the heating set points by two degrees.

➤ Replaced the lighting in the lab's Ion Cyclotron Resonance lab with newer, brighter induction lighting that lasts four times as long as conventional lighting.

"A lot of the measures we're putting into place are things we tried before. Maybe it was a little costly at the time, or we got too many complaints and we dropped it," said Facilities Management Director John Kynoch. "But during the past couple of years, gas prices went so high that a lot of people started thinking about energy efficiency in more everyday terms, and revisiting some of those things we'd initially suggested made more sense. People are willing to put up with a small inconvenience here or there if there's a measurable result."

Maintenance and Construction Superintendent Richard Brooks supervised the unloading process when several semi trucks showed up on a muggy summer day to deliver the lab's four new helium tanks. The tanks will make pressurizing, storing and reusing the lab's costly helium supply easier. *Photo by Amy Mast*

Kynoch said that once funding is in place, his group also plans to install water-efficient toilets and lower-wattage (but just as bright) lighting in office space.

Streamlining support infrastructure

The magnets that eat up the bulk of the lab's energy usage have a "big three" of support resources: electricity, water and supercooled liquid helium. Electricity provides power, while water and liquid helium temper the heat created by all that energy. These big three come with some big bills; in addition to that $400,000 monthly electric bill, add in $1.3 million per year in liquid helium.

There's no way around it — the Magnet Lab uses a lot of water, about 250,000 gallons on a typical summer day. About 200,000 gallons of that water evaporates in the lab's cooling tower while the other 50,000 gallons run out of sprinklers and back into the ground. Kynoch says his team is exploring ways to improve that ratio.

As for helium, while there's a helium recycling system in place, capturing and reusing a colorless, odorless gas can be a pretty tricky proposition, one that Kynoch describes as "challenging and expensive." Helium used to keep the magnets cool heats up and boils. The boiled-off gas is captured and piped through a system where it's purified and re-cooled.

Sounds great, but there are three big problems. First, the system that's in place can't keep up with the amount of helium being used in the lab's magnets. Second, the system is full of holes — literally. The pipes that carry helium through the building are made with PVC and for every leak technicians find and repair, Kynoch says, several more spring up. Third, helium is a natural resource, and while it is one of the earth's most plentiful elements, it must be extracted from natural gas fields and then purified. This supply won't last forever, so conserving and reusing the helium the lab buys is the environmentally responsible thing to do.

Kynoch says the lab will eventually purchase a new stainless steel recovery and purification system. With it in place the lab ➔

Recycling bins like this one wait near each of the lab's printing stations and in each office area. Recycling stations for bottles and cans also dot high-traffic areas of the lab.

could go from recovering 30 percent of its used helium all the way up to 80 percent. Do the math, and that $2.5 million needed to update the system starts to make a lot of sense. The system could pay for itself in about two and a half years. Helium storage is already improving, with four new tanks capable of storing the equivalent of 9,812 liters of liquid helium behind the lab, enough to power the lab's biggest superconducting magnet for two months.

The lab's biggest energy monster, however, is the plain old electricity used to ramp the magnets up to their super-strong fields. Last year, DC Program Director Eric Palm was part of a team charged with rethinking how the lab uses energy. Instead of giving magnet users a limited amount of time to spend in the experimental "cells" that house the magnets, the new system allows more flexible time, but puts users on an energy budget. Now, scientists have all the time they need to solve problems or make repairs during an experiment — but they have to watch the bottom line when it comes to energy.

"Many users didn't like the change at first. In the past, we asked people to be energy-conscious, but they weren't truly aware of their contribution to the power bill, and without things being quantified it's hard to really see your own impact," said Palm. "And the numbers were astronomical. Somebody sitting at full field in the hybrid will cost about $3,000 per hour for the energy bill alone."

Palm said because of the energy budget, people are more aware of how much energy they are using.

"Like anybody with a budget, you're really squeezing at the end of the month, trying to make everything fit," he said. "People are really thinking ahead of time and mapping out what they want to do, and it really has made us partners in saving energy."

The amount of energy used in a magnet is proportional to the magnetic field squared, meaning that conducting an experiment at 20 tesla uses only a fourth as much energy as the same magnet at 40 tesla. With that in mind, researchers are also being encouraged to collect data with the minimum magnetic field needed to get the results they're after. "Around here, money-saving and being green can be the same thing, which is great. This kind of approach saves us a lot of money and energy, which we can use for other things," said Palm.

Building greener magnets

Another way to conduct leaner, greener research is to rethink the way magnets themselves are built. The Series Connected Hybrid, currently under development by the Magnet Lab, is one of two ambitious attempts in that direction.

A key advantage of the new magnet, which is a hybrid of a resistive and a superconducting magnet, is that it will use one-third less power than traditional all-resistive magnets. That means experiments can be performed at lower cost and for longer time frames than would be the case using existing all-resistive magnets. Resistive magnets require both electricity and cooled water while being used; superconducting magnets require little or no electrical power to run once they are brought up to full field so long as they are cooled to ultra low temperatures. Eventually, multiple numbers of such hybrid systems will increase the number of experiments that can be carried out at the lab each year.

Even more ambitious are plans to build a 32 tesla all-superconducting magnet. New materials have been evaluated and tested that far exceed the performance of niobium, the material that has been used to build most superconducting magnets up to this point. Niobium-based superconducting magnets are limited to a field of about 23.5 tesla.

"The average cost for a resistive magnet is $774 an hour, and the lab's 20-tesla superconducting magnets are $18 an hour," said Tim Murphy, director of the lab's Millikelvin facility. "Measurements that require sitting at high fields for long periods of time would greatly benefit from a 32 tesla superconducting magnet, since they could sit at high fields for days without incurring huge electrical costs."

Recycling on a grand scale

There are almost as many different ways of recycling materials the Magnet Lab as there are materials. The lab's recycling program, in place for the past three years, now gives new life to about 65 percent of all trash leaving the lab.

It takes a lot of packaging to safely deliver scientific and other equipment to the lab: 120 pounds of cardboard are recycled by the lab each week. Packing peanuts from deliveries are picked up by UPS, which reuses them in new packages. Stations for regular office paper, plastic, glass and aluminum are stationed throughout the building, but the lab also recycles difficult-to-dispose-of items such as scientific equipment and computers. Even wood from shipping pallets is picked up by Florida State University and ground into the mulch that surrounds campus buildings.

When contracting upgrade and replacement projects on the lab's infrastructure, Facilities Engineer Sean Coyne says that the lab generally specifies that all recyclable waste materials from those projects is disposed of properly. A recent update of the fire alarm system yielded four tons of recyclable conduit.

"We recycle the waste metal from the welding shop and the machine shop as well. Usually it's lots of small stuff, but we've recycled as much as eight tons at a time," said Coyne.

Taking a long view

There's no way around the fact that the lab uses a lot of energy, but in such a big place, small changes like the ones described here really add up over time. Big steps — such as the 32 tesla all-superconducting magnet — may take longer, but when they're successful, they'll mark a permanent departure from the old standards of energy use. And who knows? Maybe some of the material magnet technicians use during assembly of the new magnets will be making its second trip to the Magnet Lab. ■

Recycling at the Magnet Lab, 2006-2009, in pounds: