momentum

Institute on the Environment • University of Minnesota

COLD CLIMATE
Hot Prospects

POLAR POWER
solar in the northland

Mapping Antarctica from outer space

CHANGING THE WORLD *via* **DOGSLED**

Q&A *arctic circles with* **WILL STEGER**

... plus **Penguins!**

&

SURVIVAL GUIDE: *Geoengineering* The green label **OVERLOAD** Keeping **NANOTECH** *in check*

Hold the Red Herrings, Please

Lately, I've noticed how easy it is to get distracted by the small things and miss the big picture. A symptom of this problem is society's focus on environmental red herrings, or commonly held beliefs that distract us from the real issues.

For example, a lot of people think that expanding urban areas are gobbling up the world's natural areas and farmlands. But on the global scale, urban areas are tiny—less than 1 percent of the earth's land surface, to be exact. By contrast, the area devoted to agriculture covers more than 35 percent of the planet's land surface. *Reality check: If you're concerned with preserving biodiversity and protecting ecosystems, focus on expanding agriculture, not suburbia.*

If we really want to build a more sustainable future, we need to get our priorities straight.

Thanks to notable writers and activists, there's also a widespread belief that locally grown food is better for the climate than food grown elsewhere. This stems from the notion that transporting food is a major source of greenhouse gasses, and a significant contributor to global warming. But the numbers don't add up. Global food transportation represents a miniscule portion of our collective emissions. Given the vast economies of scale seen in large-scale agriculture, the emissions associated with shipping large containers of food may actually be lower than those caused by local producers. *Reality check: If you want to reduce greenhouse gas emissions related to agriculture, focus on tropical deforestation, methane emissions from rice fields and cattle, and nitrous oxide emissions from over-fertilized fields.*

Let's not forget bottled water—an industry that many people blame for global freshwater problems. Yet, while the plastic bottles used in the process may be wasteful, the actual water argument is hard to figure out. To make one bottle of water, it takes one bottle of water. Pretty simple, right? In contrast, to make one cup of coffee, it takes about 140 liters (37 gallons) of water—mostly to grow the beans. To make one hamburger, it can take up to 2,400 liters (634 gallons) of water. And globally, about 85 percent of our water is used just to irrigate crops. *Reality check: If you're worried about the sustainability of our freshwater supplies, focus on irrigation and industry. Bottled water is merely a drop in the bucket.*

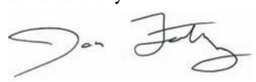
The list of distractions goes on and on. In the grand scheme of things, these are relatively minor issues—symbolic, but little more. If we really want to build a more sustainable future, we need to get our priorities straight. We can start by aggressively supporting energy efficiency throughout the economy, followed by substantial investments in real-world renewable energy systems.

We also need to redouble our efforts to slow tropical deforestation (one of the single-biggest sources of greenhouse gas emissions, as well as the main driver of biodiversity loss). Moreover, we must make huge investments in water efficiency, especially where it matters most: agriculture and industry.

In this issue of *Momentum*, we focus on the people, programs and issues that are making a real impact in the world. We explore solar innovations in northern climates. We tackle the questions surrounding geoengineering, nanotechnology and geothermal power. We spotlight an online learning program that's engaging students across the globe. No red herrings in here.

Rather than sweating the small stuff, let's roll up our sleeves and get to work on the big issues. We don't have a moment to lose.

Jonathan Foley



Director, Institute on the Environment
jfoley@umn.edu

momentum
WINTER 10 – 2.2

director JONATHAN FOLEY

communications director TODD REUBOLD

managing editor EVE DANIELS

art director SARAH KARNAS

webmaster MICHELLE BEAMAN

video producer BETH M. ANDERSON

contributors
JAMAIS CASCIO, JOSEPH HART, MARY HOFF, MAGGIE KOERTH-BAKER, JOSH KOHANEK, JENNIFER KUZMA, JESSICA MARSHALL, FEN MONTAIGNE, NATHAN MUELLER, JAMES PROVOST, STEPHANIE SZUREK, MARK THOBURN, MELANIE WARNER

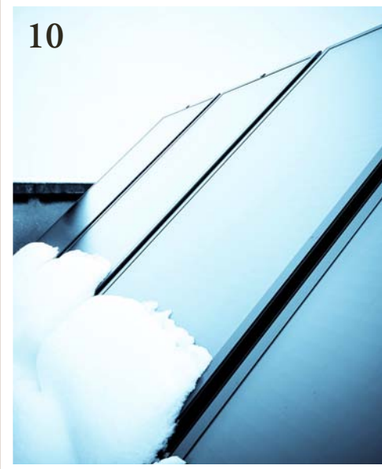
printing BOLGER VISION BEYOND PRINT

Momentum is published three times per year by the University of Minnesota's Institute on the Environment. To change your address or to request an alternative format, contact Eve Daniels, momentum@umn.edu, 612-626-2670.

The IonE is committed to sustainability. This magazine is printed on environmentally-friendly paper with an average of 58% recycled fiber and 33% post-consumer waste.

FEATURES

DEPARTMENTS



River Savvy

Nearly 50,000 students attend the University of Minnesota at any given time. Thanks to the **Gopher Ranger** program, many of these students are gaining a new respect for the river that runs through their campus. Led by the IonE's River Life program and the National Park Service, this hands-on learning effort connects undergrads from across majors to the Mississippi National River and Recreation Area—the national park designated for the 72 miles of Mississippi that flows through the Twin Cities metro, in which the U of M is located. The students start by exploring and learning about the river, before moving into more advanced experiences like assisting with canoe trips and restoring natural habitats. Visit **environment.umn.edu/riverlife** to learn more about River Life's programs and partnerships.

We Have a Winner!

This past November, *Momentum* took home awards from all five categories we entered in the 13th-annual **Minnesota Publishing Excellence** competition, including: Gold, Best Overall Publication; Gold, Best Single Cover (premiere issue); Gold, Best Feature Article (spring/summer 2009 cover story); Silver, Best Publisher's Letter (spring/summer 2009 Director's Note); and Bronze, Best Overall Design. *Momentum* was judged as part of the Special Interest, Under 60,000 Circulation category, competing against a number of popular regional magazines. Here's to an outstanding first year and a lot more to come.

Rain Garden Renaissance

Minneapolis' Powderhorn Park community is expanding the definition of "green thumb." The three-part film, ***A Neighborhood of Raingardens***, shows how local nonprofit Metro Blooms is working with residents to install 150 rain gardens throughout the neighborhood. Their goal: Clean up Powderhorn Lake. Part 1 of the film explained rain garden ecology and looked at Metro Blooms' planning and volunteer recruitment, along with the challenges related to the monitoring plan. Scheduled for production in summer 2010, Part 2 will document rain garden installation, which will entail a frenzied pace of design, excavation and planting. Mark Pedelty, an IonE resident fellow and an associate professor in the U of M's College of Liberal Arts, has received a grant from the Minnehaha Creek Watershed District to support Part 2, in addition to funding from the IonE.

Inspiration to Application

In fiscal 2009, the IonE's **Initiative for Renewable Energy and the Environment** invested nearly $6.3 million in 28 research projects. Close to $900,000 in additional matching funds are earmarked for projects that could bring another $13.6 million to the U of M and its partners. Check out IREE's 2009 Annual Report to see how we're advancing the development of economically and environmentally beneficial renewable energy systems. **environment.umn.edu/iree**

Big Questions

How do we feed the world without destroying it? That's the first topic we tackle in the IonE's new Big Question video series. Watch "**Feast or Famine**," share with other inquiring minds—and look for our next installment: *Have we pushed Earth past the tipping point?*

▶ *Feast or Famine* received more than 7,000 views in its first two months on YouTube.

Academic Accolades

With the help of some high-status awards, two IonE resident fellows are taking their research to the next level. Regents Professor **Peter Reich** (pictured) won this year's BBVA Foundation Frontiers of Knowledge award in ecology and conservation biology. Reich, of the U of M's Department of Forest Resources, was honored for his work in global metabolic plant ecology. And **Ibrahim Volkan Isler**, an assistant professor in the U of M's Department of Computer Science & Engineering, is among the 2010-12 recipients of the McKnight Land-Grant Professorships for his research on "Googling the Planet: Robotic Sensor Networks for Environmental Monitoring." Congrats!

Lectures with Life

Since launching our **Frontiers in the Environment** lecture series in fall 2009, some 2,500 people have watched, listened and learned in person and online. Each Wednesday at noon (CT), our speakers explore the frontiers of knowledge in climate change, renewable energy, public health and many other environmental hot topics. If you can't make it to St. Paul, Minn., you can join us for the live Web broadcast. Visit **environment.umn.edu/news_events** to link to the current Frontiers schedule, along with all previous lectures. Don't know where to begin? These excerpts from the fall/winter 2009 archive might help.

"We're passing tipping points in the designed environment as much as we are in the natural environment, because both are caused by the same Ponzi-like scheme that has driven—and continues to drive—our relationship with nature and each other."

THOMAS FISHER
Resilience in the (Designed) Environment (9.30.09)

"If I want to replace all the petroleum that's consumed in the entire United States [with solar energy], then I need almost 15 million acres of land and 685 million solar dishes."

JANE DAVIDSON
Solar After Dark: Storage Options (10.7.09)

"About 100 billion gallons of oil go toward the production of polymers every day. That's enough to fill the Metrodome 200 times a year."

MARC HILLMYER
Plastics from Plants: Tomorrow's Advanced Materials (11.04.09)

"Agricultural expansion from land clearing, an increase from meat and livestock emissions, and from heavier nitrogen fertilization, will all contribute greatly to global greenhouse gas release in a way that, right now, is barely part of the discussion."

DAVID TILMAN
Food, Energy and Global Climate: Solving the Trilemma (10.14.09)

"Throughout North America, there are many examples of colonial and fish-eating birds having reproductive problems or developmental problems as a result of exposure to toxic chemicals."

DEBORAH SWACKHAMER
Fixing our Toxics Problem: Ivory Tower or White Castle? (10.21.09)

"After 35 days, we had nine meters of mud to our name—and the possibility of a complete and utter failure."

TOM JOHNSON
Mud in the Eye of the Beholder: Unraveling Climate Past and Future in the African Tropics (11.11.09)

environment.umn.edu

WATCH

We hear about the global water crisis all the time, but nothing drives the problem home like seeing its effects first-hand. This past summer, a team of up-and-coming engineers not only witnessed the problem, but had the rare opportunity to solve it. As part of an Engineers Without Borders project, the University of Minnesota student group implemented a solar-powered water supply system for an entire school and its surrounding villagers in Mulobere, Uganda. And the IonE's **BETH ANDERSON** (right) was there to capture the story on video. Her documentary, *Water for Mulobere*, premieres April 27 in Minneapolis. Check out the movie trailer online.

Common Sense
Biofuels & Sustainability

"If you're a market optimist, you see biofuels as a waste. If you're a resource pessimist, you see biofuels as a fool's gold for energy that will only aggravate the burdens on our planet. Neither view has it right."

Excerpt from John Sheehan's blog
Explore all four IonE blogs online

READ
(AND COMMENT)

BE SOCIAL
& WIN!

On April 16, we'll enter all of our followers (at **twitter.com/UMNIonE**) and fans (at **facebook.com/UMNIonE**) into a drawing for some cool prizes:

$100 men's and women's gift set (two winners) from **SmartWool**, including the Cozy Glove, Cuffed Beanie, Neckgaiter and performance socks, made with soft New Zealand Merino wool—a sustainable, renewable and natural resource.

$100 gift card (one winner) from **Whole Foods Market**, the world's leading retailer of natural and organic foods, with over 200 stores nationwide including Minneapolis (Lake and Excelsior) and St. Paul (Grand and Fairview).

WHOLE FOODS MARKET

Will Power

Interview by NATHAN MUELLER

Dogsledding from Russia to Canada via the North Pole? Check. Trekking 1,600 miles across Greenland? Check. Traveling the longest-possible route across Antarctica? Check. In the past 45 years, polar explorer and environmental educator **WILL STEGER** has journeyed to the ends of the earth to raise awareness for some of the most vulnerable ecosystems on the planet. A Minnesota native, Steger is a true eyewitness to the dramatic environmental changes occurring in polar regions. When he isn't exploring, he and his foundation are working to catalyze national and international leadership on climate change. *Momentum* caught up with Steger shortly after he returned from "Expedition Copenhagen" with a delegation of 12 Midwestern youth.

"Working on the environment is like pushing a big stone up a hill: It usually rolls back on your feet a little bit. It hurts, but you've just got to get your momentum and push it up, and you get an inch at a time."

HOW WAS YOUR EXPERIENCE AT THE CLIMATE CONFERENCE? It was very positive. … We saw international cooperation around climate change. Few issues have ever brought the world together like this, in a positive way where everyone's looking for a solution. … I think it was premature to think we were going to get a treaty out of this first step, but it was the first major step. Working in climate issues for 20 years, this was a different stage, a different plateau, almost an affirmation of my hard work behind the scenes to see this actually happening.

WHAT ENVIRONMENTAL CHANGES HAVE YOU OBSERVED OVER THE YEARS? Every ice shelf I've traveled on is disintegrated. … We've lost almost 50 percent of the sea ice on the Arctic Ocean in the summer now. So, big changes. … And the speed at which this is happening is extremely alarming.

HOW ARE INDIGENOUS COMMUNITIES ADAPTING? The Inuit people are basically marine people. … The way of getting their meat from the sea is on the ice—seal, walrus and so forth, fishing. With the change of the ice, their hunting is being restricted; migration patterns are changing. Their life is upside down. A lot of communities now are going into fishing rather than hunting. Inuit are very adaptable people, so I think in the long run they're going to be just fine because they can adapt to the climate. … When you start losing the snow pack on the Himalayas and that water—3 million people rely on it for energy and food in one way or another. Twenty years from now, that's going to be diminishing. Can we adapt to that? That's the question.

WHERE DO YOU FIND INSPIRATION? Working on the environment is like pushing a big stone up a hill: It usually rolls back on your feet a little bit. It hurts, but you've just got to get your momentum and push it up, and you get an inch at a time. … Copenhagen was the ultimate inspiration because here was a dream come true. All the countries in the world, all the power brokers of the world are there around one mission: trying to figure this out. … That was inspiring to me, to look at where this has come in 20 years. In the mid-'90s, I couldn't say "global warming" in the media because I'd lose my sponsors. It was that bad. But here we are. It's just amazing the progress we're making. Q&A

Visit **willstegerfoundation.org** to learn more.

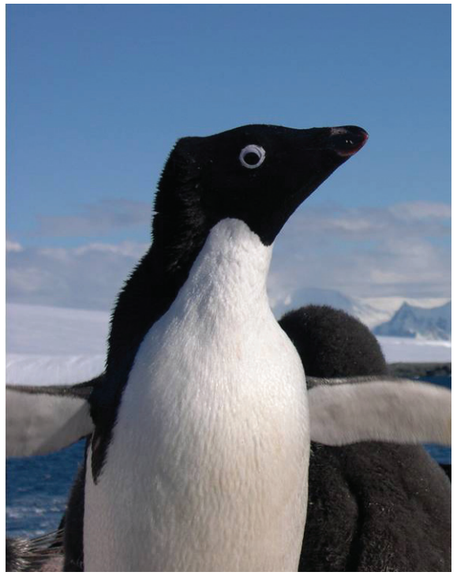
NATHAN MUELLER is a research assistant with the Institute on the Environment's Global Landscapes Initiative.

On Thin Ice

Photos and text by FEN MONTAIGNE

Few places on earth are more breathtaking—or more ice-bound—than the Antarctic Peninsula, the 900-mile finger of land that juts toward the tip of South America. But the peninsula is warming rapidly, with winter temperatures soaring 11 degrees Fahrenheit in the past six decades, roughly 90 percent of glaciers in retreat, and sea ice blanketing the waters off the peninsula's west coast three months less each year. In the northwestern Antarctic Peninsula, rising temperatures have had a profound impact on sea ice-dependent **Adélie penguins**, the classic, tuxedoed penguin that breeds exclusively in Antarctica. Over the past 35 years, the number of Adélies in the vicinity of the U.S.'s Palmer Station has plummeted from more than 30,000 breeding pairs to 5,600 today. For polar scientists such as Bill Fraser, who has studied Adélies at Palmer Station since 1974, global warming is not an abstraction. He confronts it everywhere he looks—in the receding glaciers and in the swiftly disappearing populations of Adélie penguins (pictured here in one of the colonies Fraser studies) that have been his life's work.

FEN MONTAIGNE is a journalist, an author and the senior editor of the Web magazine, *Yale Environment 360*. While researching an upcoming book on the warming of the Antarctic Peninsula, he spent five months working on Bill Fraser's field team.



Now What?

Interviews by TODD REUBOLD

They came. They met. They left. By the best accounts, this past December's climate change negotiations in Copenhagen set the stage for future discussions. By the worst accounts, the meeting was a flop. As the world waits for an international global warming treaty, *Momentum* sat down with Berkeley professor **DANIEL KAMMEN**—a nationally-recognized energy policy guru—to get his take on the future of clean tech and renewables in an uncertain climate.

***Momentum*: Some argue that limited progress was made in Copenhagen.**

Kammen: No argument needed.

What do you expect will happen now in terms of private and public investment in renewable energy?

I don't think it's going to change the investment patterns much at all. The reason is that the renewable energy market is booming around the world. You look at what's happening with solar and wind essentially across all of Europe, solar in California and New Jersey, plus the wind markets that are evolving from Minnesota down to Texas. And China installed more wind power last year than the U.S., so I think the renewable energy markets are truly going great guns.

If not a carbon market, what's driving the development?

Those markets are basically being driven more by local regulations, state renewable portfolio standards or feed-in tariffs than by what the carbon market would do anyway. For example, California's solar is doing very well, but our greenhouse gas law doesn't even really start until 2012. Right now, the real constraint [to growth] has been the available supply of wind turbines and solar panels and, of course, the financial crisis.

It seems like putting a price on carbon would spur even greater demand, though.

The price on carbon moves us from energy policy into climate policy. And that's where the lack of action, the failure in Copenhagen, really hurts. … It was always an incredible stretch to think that a new administration could arrive in Washington, bring in a whole new staff, develop a coherent climate policy, get it accepted not only by the U.S. House and Senate and U.S. industry, but also convince Asian and European partners, allies and competitors that we had truly changed our climate policy all within the first 11 months of a new administration. You'd like to think you can do anything, and the U.S. does have this "wake up at the 11th hour" mentality. But we went into Copenhagen with a very troubled setup.

Meaning?

First of all, not as much came out of the U.S.-China summit on energy when President Obama went to Beijing in November as one would like. Second, even before President Obama went to China, and I was there during that visit, he made this important G-20 stop in Singapore, where multiple heads of state announced that Copenhagen wasn't going to produce any binding agreement. So, these leaders had done one of two things: They had either lowered expectations or they had essentially declared that Copenhagen would be a failure two months before the meeting.

What's needed to get an international agreement on climate, then?

The way to get major game-changing political action is not to try to sit down with 180 nations and negotiate, where Vanuatu and the Seychelles and Russia and the U.S. are individual players, with one vote per one nation. These things come together when a small group gets together, figures out what works for them, and then other nations get together to look at it, kick the tires, change it or just simply adopt it. That's what's needed now. The U.S. and China arguably started a dialogue but haven't finished it. Europe has already staked out a position, which makes sense environmentally but hasn't proven to have political traction yet.

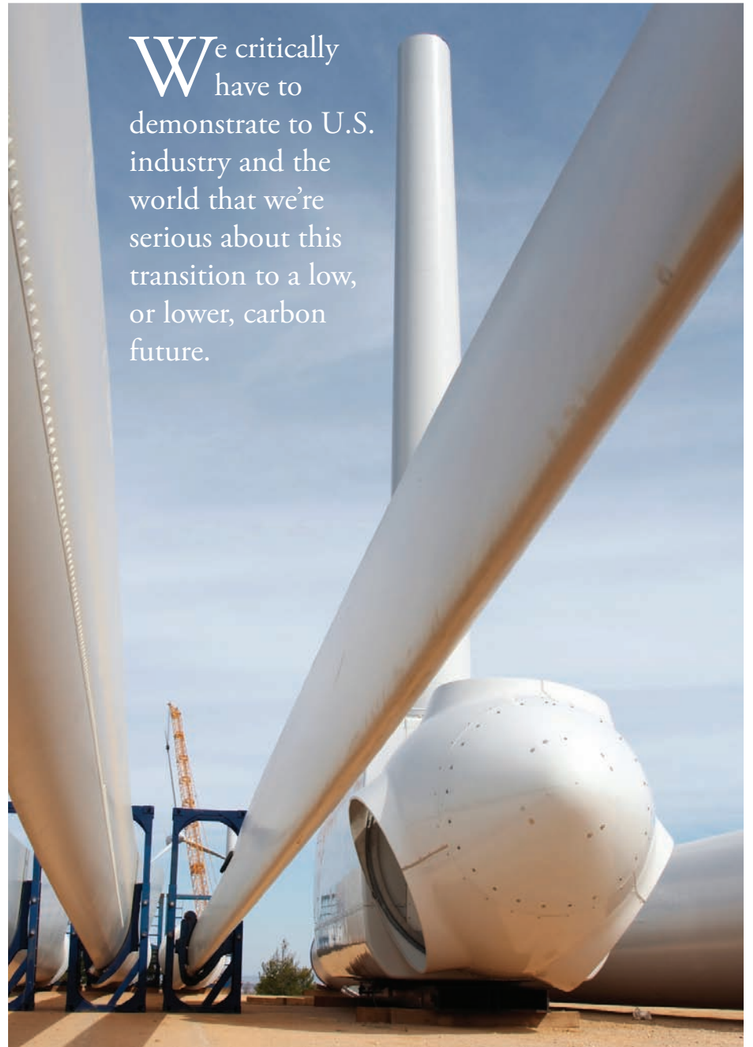
You mentioned a climate bill versus an energy bill. Which do you see coming first in the United States?

If I forecast over a year ago, I would've said I think what's going to happen is there's going to be an energy bill and then there will be a climate bill. … Things are jumbled now. I know what needs to happen, though, and that is: We critically have to demonstrate to U.S. industry and the world that we're serious about this transition to a low, or lower, carbon future. And we have to move away from nice pronouncements about what we plan to do in 2050 and really figure out what we're going to be doing by 2020.

What do you make of the United States' current position in the world when it comes to clean tech and renewable energy development?

We trail, unfortunately, in many of these areas. The real irony is that many of these technologies were first developed in the U.S. After Carter, we had a period of absolute neglect of energy research. While a few states like California, New Jersey, New York and Wisconsin did things, we didn't progress as a nation. So, other countries who took this seriously—everything from hybrid vehicles to wind turbines—took U.S. innovations and commercialized them. The U.S. is still exceptionally innovative in some areas such as new wind turbine technology, energy storage and solar. But every day that the U.S. isn't developing actual clean energy products for the market is a day we're falling behind.

The price on carbon moves us from energy policy into climate policy. And that's where the lack of action, the failure in Copenhagen, really hurts...



Investment Climate

TODD TAYLOR, a lawyer with the Minneapolis-based law firm Fredrikson & Byron and a noted clean-tech expert, weighs in on:

GROWTH

"There really hasn't been a robust carbon finance market in the United States to date and deals are still getting done. Many venture capitalists tell their companies not to look for government programs to help their business succeed. Venture finance doesn't tend to be too worried about short or medium-term regulations. The lack of carbon regulation probably matters more in the context of a missed opportunity for faster growth."

INCENTIVES

"Tax credits for investors are very helpful because they provide an incentive for angel investors and start-up capital investors to contribute. Wisconsin, with their angel network, has a type of public/private partnership between the state and investors. Minnesota needs to do something like that, and I know there are a number of efforts underway to get that done. The state had an angel tax credit that got vetoed because of some other budget issues, but it needs to come back not just for clean tech, but for investment in Minnesota overall."

INNOVATION

"There are some really amazing things coming out of universities and private companies in the U.S. that you just don't see from a lot of other countries. The problem, though, is we're not so great when it comes to support for commercialization of new technologies. Whereas in Germany, it may be kind of a bread-and-butter technology that someone's developed, but there's a heck of a lot of support to get it commercialized. I think having too much control by the government would stifle innovation, but too little means you have all these great ideas that never go anywhere. So we need to find a balance."

POLAR ENERGY

THE FUTURE LOOKS BRIGHT FOR NORTHERN LIGHT.

by MARY HOFF

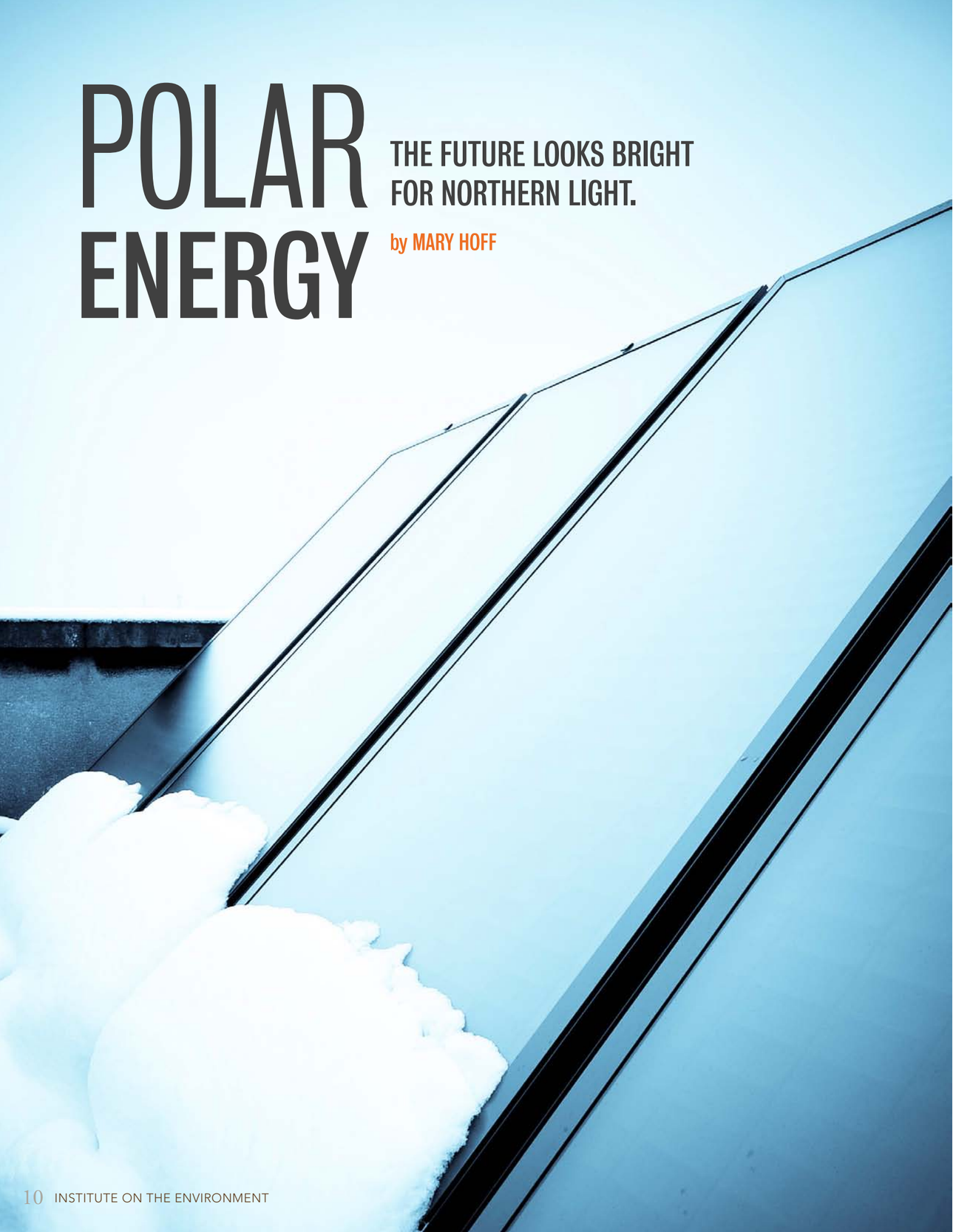


PHOTO: SEB WESTON

Not to be grumpy about it or anything, but the sun just set, and it's only 4:32 p.m. Next time we'll see it? Sometime—but not much—before 8 tomorrow morning.

If the cloud cover breaks.

Hmmph.

Thanks to how the earth's axis angles relative to its path around the sun, those of us who live beyond 45 degrees north latitude have learned to get by on relatively little solar input at least half of each year. We eat breakfast in the dark, wear warm clothes and burn out our car headlights en masse each January.

Yet as concerns over energy security, fossil fuel prices and global warming grow, northlanders, like others, are increasingly interested in exploiting the sun's energy for everything from heating our homes to powering our iPhones.

But is it reasonable? Does solar make sense in places best known for cold and darkness? Where the need for heat and light is inversely proportional to what the sun provides? Where frigid temperatures, ice storms and snow routinely challenge materials and systems of all sorts, from household plastics to electric grids?

Absolutely, says Larry Kazmerski, executive director of science and technology partnerships with the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). The solar resource anywhere in the continental United States, including Minnesota, "is more than acceptable" to make harvesting its energy worth considering, Kazmerski says.

Currently, less than 1 percent of the electrical power generated in Minnesota comes from the sun. But interest in solar photovoltaic technology is growing across the Midwest and in other northern places.

Sunlight may not be as abundant in cold, dark climates as hot, sunny ones. But it's abundant enough to be a part of a diversified energy picture. And technology and policy innovators are discovering how to make it even more so, with new and better ways to capture and use the energy in the sun's rays—accompanied by creative incentives for mainstreaming our planet's most ubiquitous power source.

TAPPING LOW-TECH

Talk solar energy, and many of us tend to think high-tech—massive parabolic mirrors concentrating incoming radiation, photovoltaic panels plastered with semiconductors sucking electrons through interatomic space. But in northern climates, one of the most worthwhile approaches to exploiting solar energy is at the other end of the spectrum: passive solar, which uses simple, strategic, sun-sensitive design to light and heat indoor spaces.

It's an application where northern climates shine. In the sun-drenched south, space heating is about the last thing folks are looking for. In the chill north, however, it's literally a lifesaver. Instead of working to ward off the sun's rays, cold-climate denizens welcome them in. With the sun's low arc in winter, that's not a difficult thing to do. At noon on a sunny day, the horizon-hugging orb can easily shine right through a south-facing window, bringing with it light and heat and reducing the need for making both from nonrenewable energy sources.

"I think of passive solar actually as a good fit for Minnesota," says Pat Huelman, coordinator of the University of Minnesota's Cold Climate Housing Program. "We have the need. We have the sun when it's very, very cold. … If we build an efficient structure and insulate it well and make it airtight, then it's very feasible to provide much of the space heat need with passive solar elements."

Huelman's own home could serve as Exhibit A. Designed for minimizing use of fossil fuels, it combines the best of conservation, efficiency and solar energy. Across the south face stretch 230 square feet of windows. On crisp days in January, when the sun blazes through bright and clear, the light switches are off and the furnace doesn't run. And when there's fresh snow, even reflected radiation contributes—a boost of up to 20 percent, Huelman says. All told, he figures his fuel bill is one-third less than it would be without the sun's input. This past year, he spent less than $400 to heat the 3,100-square-foot house.

To Huelman, passive solar is renewable energy's best-kept secret.

"Every home has a little bit of it, but we don't see it intentionally optimized," he says. "I'm hoping that changes when people realize how inexpensive it can be through good design to incorporate passive solar."

ALL STEAMED UP

It may be 20 below outdoors, but Whistler, British Columbia, Mayor Ken Melamed is bathed in the heat of the sun—literally. Head of one of the venue cities for the 2010 Winter Olympics (also one of the "greenest" communities in Canada), Melamed recently installed a solar hot water system on the roof of his home. "Generally, we are pleased," he reports.

Mayor Melamed is far from alone. When it comes to solar energy technologies, domestic water heating is among the most viable for high latitudes. "There's always a need for hot water, year-round," says Kurt Koegel, spokesperson for Solar Skies, a Starbuck, Minn.-based solar thermal collector manufacturer. "That's where you get the most bang for the buck."

With a thermal efficiency averaging an admirable 35 percent over the course of a year, U of M solar energy researcher Jane Davidson says solar hot water systems can be capable, even in Minnesota's climate, of meeting a home's entire needs. These systems are not without challenges in northern latitudes, however. As anyone who has suffered the indignity of burst pipes can tell you, water freezes up in no time if left out in the cold.

As a result, says Minnesota Department of Commerce energy specialist Phil Smith, solar thermal applications in a climate like ours need to use evacuated tube or flat plate systems, which gather the sun's heat with a

second substance, then transfer it to water. The 104 Solar Skies solar thermal collectors installed on the roof of Kalahari Resorts in Wisconsin Dells, for instance, use tubes full of propylene glycol to capture the sun's heat, and then pass it along to water circulating in separate pipes.

"You have to protect against heat loss and against freezing and use lots of insulation," says Koegel. But with such safeguards in place, he says, solar can work for "anyone who uses hot water," no matter the latitude.

HOT STUFF

Heating indoor spaces demands enormous amounts of energy—and the colder the climate, the greater the demand. In the remote town of Sisimiut, Greenland, 45 miles north of the Arctic Circle, 18 vacuum tube and nine flat plate solar collectors soak up heat from the sun during summer's 24-hour daylight. The heat is used to warm the classrooms of Knud Rasmussen Folk High School.

Specially designed for top performance in the extreme north, the vertically aligned panels can catch sun on both sides—including light reflected from snow—and withstand temperatures down to minus 58 F. Heat exchangers first transfer solar energy to the hot water system. When that's fully charged, they switch over to space heating. The system reduces the school's consumption of costly fuel oil by half during the summer, saving an estimated 40 to 50 tons of greenhouse gas emissions each year.

There is no question the sun can be a great source of space heat. It can be a good choice where other sources of energy are available to supplement—as will be the case with District Energy St. Paul when it adds solar to its downtown building/heating energy mix later this year. It's also handy in places where conventional sources of fuel are expensive or hard to access.

But there are plenty of opportunities for improvement. One has to do with availability. "The problem is, you have very high loads in the wintertime when it's the coldest outside and when you have the least sun," says Davidson, who's hot on the trail of one big idea for serving up solar energy even when the sun doesn't shine. As lead faculty member with the U of M's Solar Energy Laboratory, she's working on ways to gather sun energy at one time of year and use it another.

Most promising to date is a system consisting of a water-attracting liquid desiccant. In summer, sunlight heats and drives water from the liquid, transforming electromagnetic waves into thermal and potential energy. In winter, the desiccant reabsorbs water and releases heat.

With the help of a 400-gallon prototype now under construction in her lab, Davidson aims to engineer a system that works well enough to meet 100 percent of a northern household's space heating needs.

"That's our idea," she says. "If the storage can be sufficiently large, you can eliminate the cost of a furnace, and it becomes even more economical."

IMPROVING PV

As useful as solar heat and light might be, they can't run a computer, wash a load of laundry or charge electric cars. To do that demands transforming sun energy into electricity—the work of solar photovoltaics.

Currently, less than 1 percent of the electrical power generated in Minnesota comes from the sun. But interest in solar photovoltaic technology is growing across the Midwest and in other northern places. Germany, which sees less sun than Minnesota, is a global solar PV leader, thanks to strategically placed government incentives. And in far-flung locations at virtually any latitude, solar power is often the technology of choice.

NREL far-north representative Brian Hirsch has helped install solar photovoltaic systems throughout Alaska, including, in Arctic Village, what he believes is the most northerly, tribally-owned, dual-axis PV tracking system in the world. "Numerous remote 'luxury' lodges for hunting and fishing clients, and remote cabins and homes off any central grid use photovoltaic systems," he says. "Remote telecommunications, government applications and other niche uses are present throughout Alaska."

FiT FOR SOLAR

It's farther north than Minnesota. It sees less sun than most of the United States. Yet it leads the world in grid-connected solar PV capacity. What's up with Germany?

In a word, predictability. Two decades ago, the German government passed a law guaranteeing a 20-year fixed minimum payment for the electricity solar power producers generate. Known as a feed-in tariff (FiT), the law aims to give solar power a leg up by spreading the risk of trying something new across many beneficiaries.

By all accounts, Germany's FiT appears to be a rousing success. Relatively cold and cloudy though it may be, the nation expected to wrap up 2009 with more than 7 gigawatts of installed solar photovoltaic capacity. According to National Public Radio's *Marketplace*, green technologies are zooming toward the top in the German economy, potentially outpacing the nation's famed auto industry.

Other northern nations with renewable energy FiTs in place or in the works include Denmark, Poland and Sweden. Ontario's comprehensive FiT program, set into place in October, should allow the province to phase out coal-fired electrical generation by 2014 and create some 50,000 jobs, according to Ontario Power Authority spokesperson Ben Chin.

In the United States, incentives for developing solar power so far have rested largely with states. About two-thirds have focused on renewable portfolio standards, in which state governments specify a percentage of the power generated come from renewable sources. At least two U.S. states and several utilities have some version of a FiT in place, and half a dozen others are considering the approach.

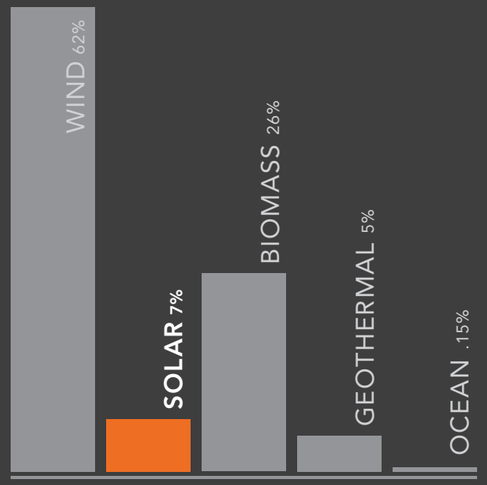
Jason Coughlin, analyst with the U.S. Department of Energy's National Renewable Energy Laboratory, says such assurances are key to getting northern solar off the ground. "It's the policies and incentives that have to take it into the realm of not only technically feasible, but also economically reasonable."

PAGE LAYOUT: TODD REUBOLD

SOLAR BY THE NUMBERS

A side-by-side comparison of solar energy in six leading countries: China, Germany, Japan, South Korea, Spain and the United States.

GLOBAL PERCENTAGE OF NON-HYDRO RENEWABLE POWER (2008)



THE COST CURVE

3.6%

From 1998 to 2008, the installed costs of grid-connected PV systems in the U.S. declined by approximately 3.6 percent (or $0.3/W) per year. The actual drop was from $10.8/W in 1998 to $7.5/W in 2008.

THE NEXT GENERATION

TWO-THIRDS

The U.S. accounts for two-thirds of global thin-film solar cell production. Thin films are made of slender photo-sensitive materials and require less energy to produce than conventional silicon-based cells. Since they're cheaper to manufacture, numerous researchers and companies consider thin films the future of solar.

SOLAR HOT WATER CAPACITY

At 67 percent, China is by far the global leader in solar hot water capacity. Turkey is a distant second at 6 percent.

SUN KING

8.2

Rays of sun hitting the earth's surface produce 8.2 million quads of BTU energy per year. By comparison, all of humanity will consume roughly 400 quads of BTU energy this year. Put another way, the sun produces more energy in an hour than humans use in a year.

MANUFACTURING

CHINA

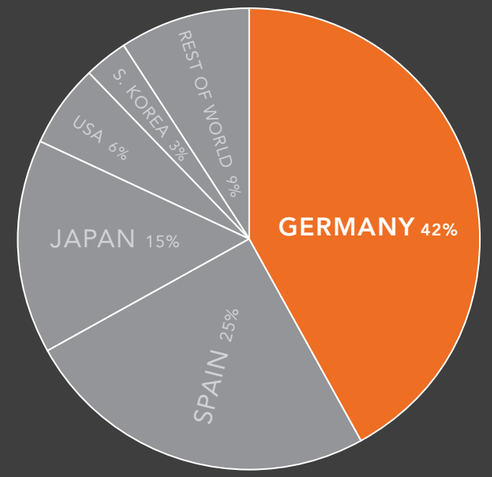
The Asian powerhouse is the largest producer of solar cells in the world today. In the late 1990s, the United States produced more than 40 percent of the world's solar photovoltaic cells. According to the Solar Energy Industries Association, this figure dropped to only 5 percent of global production in 2008.

EMPLOYMENT

75,000

More than 75,000 people were employed in the German solar industry in 2008. For the United States, the number was approximately 24,000.

GLOBAL PERCENTAGE OF GRID-CONNECTED SOLAR PV (2008)



SOURCES

International Energy Agency, National Renewable Energy Laboratory, REN21, Solar Energy Industries Association, United Nations Environment Programme and Worldwatch Institute

Photovoltaics do face a few unique challenges in upper latitudes, nevertheless. Snow, for instance, can block sun from PV collectors as quickly as it can bury one's car in a mountain of white. But installers contend that, with the proper angle, panels can easily shed the load once the sun shines. Short day lengths are also capable of dramatically limiting PV's power during winter months.

At the same time, cold and snow can have some positive implications.

"One of the wonderful characteristics of a photovoltaic module is that it actually operates more efficiently when it's cold," says Tim Hebrink, lead research specialist in solar photovoltaics for 3M. "And snow is a wonderful reflector, so if your photovoltaic module is facing a snow field or a snow-covered flat roof and you get reflection off that snow, the photovoltaic module will produce more power because of the additional light."

Hebrink and colleagues are working to develop a number of products to improve the efficiency and reduce the price of solar PV and solar thermal. Tapes, adhesives and reflective films could make the technology less expensive and more reliable—both of which will benefit northern applications. They're also working on ways to even out supply and demand over time, targeting research on improving batteries, fuel cells and capacitors for storing energy.

Other innovations that stand to boost the application of PV technology in northern climates include trackers that permit PV panels to follow the sun through its wide summer arc. Solar collectors that trap energy from diffuse, as well as direct, light also help make the most of the long days. In a 9.1 megawatt solar energy farm fired up in October, Canadian renewable energy developer SkyPower and solar company SunEdison used thin film technology rather than conventional PV, in part because of its ability to capture indirect solar energy.

At the U of M, chemical engineering and materials science professor Eray Aydil is trying to perfect a solar PV shingle that performs better in cold climates than in warm ones. The shingle is already on the market, but Aydil hopes "to increase the efficiency and long-term reliability."

"One of the wonderful characteristics of a photovoltaic module is that is actually operates more efficiently when it's cold."

ALL TOGETHER NOW

If one solar application is good in northern climates, two or more together can be even better. At Concordia University in Montreal, the new John Molson School of Business is making the most of solar in a large, cold-climate building.

The brainchild of Andreas Athienitis, scientific director for Canada's Solar Buildings Research Network, the school integrates both photovoltaic and solar thermal technologies into its siding. As they generate electricity, the PV panels also capture heat. While fans blow warm air into the building, they cool the panels and make them operate more efficiently.

On the other side of the North Atlantic, University of Oslo physics professor John Rekstad is exploring boreal applications of solar thermal panels that produce domestic hot water and space heating—and look pretty, to boot.

"Short days and a sun only a few degrees above the horizon make it more feasible to place the collectors on a south-facing façade rather than on the roof," says Rekstad. To enhance the aesthetics of such solar-paneled walls, he's developing plastic collectors that come in a variety of colors.

"Our ambition is to [help] customers see solar thermal as a solution that is beneficial for them," he says. "Hence, one needs to make solar systems appealing and sexy."

Colorado inventor Sam Weaver is capitalizing on multiple applications, too. Founder of Cool Energy, Inc., Weaver is about to beta test a third-generation prototype of a system that uses sun-warmed mineral oil for space heating in winter, and for driving an electricity-generating Stirling engine during the off season. The system is ideal for northern climates, Weaver says, because that's where demand for heat in winter and electricity in summer best balance out.

ICON, the U of M's award-winning entry in the U.S. Department of Energy's 2009 Solar Decathlon, takes yet another innovative approach to off-season solar heat. The student-designed and -built demonstration home uses excess solar hot water in summer to run a dehumidifier that cuts the need for air conditioning in half.

For ICON, heating and cooling are just the beginning. With passive solar, hot water and PV also part of the picture, this high-latitude house is literally run by the sun. In fact, it proved a net energy producer during the competition in Washington, D.C., this past October.

What makes ICON work so well? Solar integration team leader John Quinnell, a mechanical engineering graduate student, has a short answer that would make a good maxim for anyone hoping to exploit the sun's energy at high latitudes.

"Thinking," he says. "Thinking about the climate and the solar resource."

As reasons for letting go of conventional fuels grow, many expect solar energy applications in northern climates to grow as well. Exactly where and how quickly will depend on many variables, including the trajectory of technological advance and the availability of incentives to overcome innovation inertia.

But one thing seems clear: As sure as the sun will rise tomorrow, the future of solar looks bright for the northland.

MARY HOFF is a science communicator specializing in the environment, natural resources and sustainability. A regular contributor to *Minnesota Conservation Volunteer*, she has also published in *Science World*, *PLoS Biology* and *National Geographic Explorer*, and has written nearly two dozen books for children on environmental and natural history topics.

COLD CALCULATIONS

Does solar make sense in northern climates? Ask students who participated in the 2009 U.S. Department of Energy's Solar Decathlon, and you'll likely hear a resounding "yes."

The biennial decathlon challenges 20 preselected teams of college students to build the most energy efficient and attractive solar home as rated in 10 categories. Of the top seven finishers in the 2009 event, five came from north of the 40th parallel, beating out participants from stereotypically sunny spots like Arizona and Spain. Among them: the University of Minnesota's ICON solar house, with top ranking in both engineering and lighting design.

Visitor liaison Jordan Brough warms up with a hot drink on a cold morning during the event.

"What many people don't know is that we have a great [solar] resource here in Minnesota," says mechanical engineering grad student Josh Quinnell, who led the project's solar integration team. "The biggest challenge here is that we have high heating loads. It isn't the fact that we can't collect enough solar energy. We can collect as much as in most places. The downside is, we need a lot in winter."

The ICON is truly iconic of every aspect of cold-climate solar energy capture. The overall look emphasizes not only aesthetics but also passive solar benefits. The windows are strategically placed and shaded as needed to maximize winter light and heat gain (including what Quinnell estimates is an almost doubling effect of reflection from snow cover), while keeping out intense rays in the summer months. Building-integrated photovoltaics capture solar energy while providing structural integrity—and cleverly give off just enough heat to melt snow from their surface in winter.

To optimize photovoltaic output, the team used energy modeling software to calculate the perfect pitch for the roof that would meet competition parameters and also soak up bountiful sun in winter. Solar thermal flat-plate collectors on the south roof and walls heat a water-glycol mix, which in turn provides superheated water for radiant floor heating, domestic hot water, and interior-cooling dehumidification in summer.

The winning edge for the ICON solar house, says faculty advisor Ann Johnson, was its emphasis on being a good fit for the local climate all 12 months of the year. The house also scored high by including a broad spectrum of solar energy inputs. Topping it off was exceptional insulation to trap heat inside in winter and keep it outside in summer.

"That really was the key. You can't design a house to just be insulating in the winter because then it doesn't perform well in the summer," says Johnson. "The students looked at it over the 12-month year and tried to achieve a balance."

Visit **solardecathlon.umn.edu** to learn more.

PHOTOS: STEFANO PALTERA; U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

ABOVE: People tour the University of Minnesota's ICON house during the Solar Decathlon in Washington, D.C.

BELOW: This rendering shows how the ICON's solar collectors accommodate melting snow, while the panels continue to generate energy. On the south deck, the snow reflects additional light into the interior of the living and dining rooms.

SOLAR SYSTEM

PASSIVE SOLAR

ACTIVE SOLAR

PHOTOVOLTAIC

Passive Solar Thermal

Passive solar is the cheapest, lowest-tech and, by far, most common type of solar energy. Building technologies and strategies that tap this resource are all about bringing in light and heat in winter and keeping heat out in summer. Specifics include window placement, building siting and materials choices. The benefits of passive solar add up at all latitudes.

Active Solar Thermal

Both passive solar thermal and active solar thermal capture energy in the form of heat. But, unlike its passive counterpart, active solar relies on mechanical or electrical systems to do the heavy lifting. Active solar thermal can be distributed—meaning the heat captured by the solar thermal panels is used in the building where they are located—or centralized, where much bigger operations convert heat captured from the sun to electricity.

Distributed Active Solar Thermal

The most common application for distributed solar thermal systems is hot water. A larger array and a more complicated storage system can allow for solar thermal energy to provide space heating in conjunction with water heating. Emerging technologies are also using the heat captured by solar thermal systems to provide air conditioning.

Centralized Active Solar Thermal

Centralized active solar thermal systems include parabolic troughs (Concentration ratio = ~100 times normal solar radiation at the focal point), power towers (C = ~5,000) and dish/Stirling engines (C = ~10,000). The largest solar plants in this category—several with installed capacities above 50MW—are located in Spain and the United States.

Solar Water Heating

Applicable to sites across the globe, solar water heating works well in climates with widely fluctuating heating and cooling needs. The setup includes solar collectors, a water tank and pumps. Since homes and businesses use hot water year-round, such systems always have a job.

Space and Hot Water Heating

Related to solar water heating is space heating, which uses active solar heat collectors. Advances toward making the installations more versatile for northern climates include adapting them to space cooling or electrical generation once winter ends.

Solar Air Conditioning

Solar thermal cooling uses heat from solar collectors to drive chillers. In addition, desiccants can be used to draw moisture from the air and increase the cooling cycle's efficiency.

Linear Concentrator Systems

Typically parabolic troughs or Fresnel reflector systems, this technology collects energy from the sun using mirrors and heats a fluid flowing through tubes. The hot fluid is then used to boil water in a conventional steam-turbine generator to produce electricity.

Power Tower

Flat, sun-tracking mirrors focus sunlight onto a receiver on the top of a tower in this system. The super-charged sunlight is used to heat water, produce steam and power a turbine generator to produce electricity. Future systems aim to generate power even when the sun isn't shining.

Dish plus Stirling Engine

In this system, a dish concentrates sunlight to power a Stirling engine, a special type of heat engine. Dish/Stirling configurations typically have higher efficiencies than conventional PV cells.

Photovoltaic (PV)

Heat and light alone won't run your refrigerator or your future solar car. That's where photovoltaic enters the picture. In northern climates, PV makes the most sense when you can feed excess power into the utility grid in summer—when the solar collectors are cooking—and draw on your credit during darker days.

Distributed PV

Distributed PV—panels on the roofs of homes and businesses—is probably the most recognizable of all solar technologies. The systems are primarily used for electricity generation and can either be grid connected or off-grid. Industry analysts predict global sales of distributed PV will double by 2015.

Power Plant PV

Nowadays, utility-scale solar plants are gaining more and more attention. These facilities capture the sun's energy over large spaces using PV panels to generate electricity. While this approach has a clear advantage in sunny southern climates, it's being applied in Canada, Germany and Scandinavia as well.

Concentrating PV

Concentrated photovoltaic uses mirrors to focus the sunlight hitting the solar cell, thus achieving higher efficiencies, more power output and greater electricity production than traditional PV. The primary use is electrical power production.

CONTRIBUTORS: TEXT BY MARY HOFF AND TODD REUBOLD; DATA PROVIDED BY JULIA HALTIWANGER, SOLAR ENERGY LAB, UNIVERSITY OF MINNESOTA; ILLUSTRATIONS BY JAMES PROVOST; PAGE LAYOUT BY TODD REUBOLD

northern exposure

By bringing the Arctic into the classroom, the GoNorth! program is changing the world—one dogsled adventure at a time. **BY JOSEPH HART**

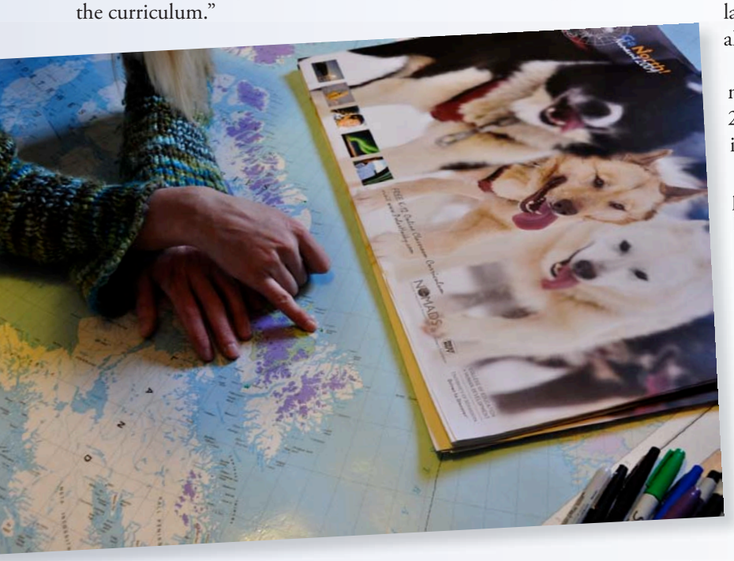
Fresh from their holiday break, the third-graders in John Clay's classroom at Eden Lake Elementary School are unusually excited about the lesson plan. Today, they're going online to "adopt" a sled dog.

Each week throughout the winter, the students log in to follow along as their dog journeys to the Arctic with a team of mushers, researchers and educators. On the way, the class explores climate change, marine science, traditional Inuit cultures and a whole lot more.

Clay's class is one of more than 4,500 around the world using the GoNorth! curriculum—a free online education program designed by the University of Minnesota's College of Education & Human Development and NOMADS Adventure & Education.

The basic idea of GoNorth! is to link students and teachers in K-12 classrooms to a real-time learning adventure. Every year, the team makes the trip to a different Arctic region. While dogsledding across some of the coldest, most remote landscapes on the planet, the team beams into classrooms via satellite to help teachers deliver lessons that stick.

According to Clay, it's an idea that helps his students understand the real-world implications of natural and social sciences, geography and other subjects he's teaching. "For this age, the hook is the dogs," he says. "They're very motivated to watch their dog during the course of the expedition, and that inspires them to engage with the curriculum."



This kind of engagement is the goal of the program, says Aaron Doering, education director for GoNorth! and an associate professor at the U of M. Traveling through the Arctic by dogsled is no small feat—weather is extreme and ever-shifting, the pace requires physical endurance, and there are always polar bears to worry about. Yet each Friday, the expedition halts to hook up satellite equipment, solar panels and laptop computers to deliver the curriculum live from the field.

"Everything we're doing and communicating on the trail is in sync with what the students are learning in the classrooms," says Doering. "What we've found in our research is that students are significantly motivated to learn in this way."

Clay sees the evidence of this first-hand. "I have students who have moved up in the grades and they're still going online to look up the program and to check up on their dog."

Part of the GoNorth! curriculum, and a key component of the expedition, involves field research for NASA, the National Science Foundation and other partners. Case in point: The team, often with the help of Arctic students, digs snow pits to collect data that can be used to fine-tune NASA satellite imagery.

It's impossible to study the environment and cultures of the Arctic without coming face-to-face with the realities of climate change and the questions surrounding sustainability. Indeed, in the five years since Doering and his colleagues launched GoNorth!, climate change has become an increasingly central concern to the people of the Arctic, and hence, the program.

Nearly 3 million years ago, Arctic countries like Greenland—the destination for this year's GoNorth! expedition—were comparatively balmy places, with warm oceans and landscapes you might see in the mid-latitudes of the United States. The ice age changed all that, layering the poles with vast sheets of ice that oozed glaciers all the way down to the equatorial latitudes.

Today, the last of those massive polar ice caps are rapidly melting. Scientists predict that, for the first time in roughly 2.5 million years, the Arctic Ocean will be free of summer ice within the decade.

Climate change is affecting the Arctic at a much faster pace than the rest of the world, in part because of "feedback loops" that magnify the impact of a warming climate. For example, white snow reflects solar heat back into the atmosphere, while black dirt absorbs it. Thus, as the Arctic snow-cover melts, it uncovers dirt, which heats up, accelerating the rate of melting in the snow that remains.

For people living in the Arctic, climate change is radically altering their hybrid of traditional and contemporary customs. Greenland, for instance, is surrounded by sea ice for most of the year. For generations, hunters have followed traditional migration routes to catch the prey that feeds their communities. Today, as sea ice retreats, this centuries-old practice is dying out.

As they've grappled with the rapid changes in their environment, the Arctic Inuit have become leaders in advocating for a global effort to reverse climate change, thanks in part to their GoNorth! connection. Through the program's "What is Climate Change to You?" project, students at schools in the circumpolar Arctic work hand-in-hand with scientists and each other, connecting online with other classrooms around the world to share their observations and messages of change.

"Everything we're doing and communicating on the trail is in sync with what the students are learning in the classrooms."

During December's Copenhagen summit, GoNorth! sponsored a pan-Arctic delegation of youth from Greenland, Alaska, Northern Europe's Sápmi region, and Nunavut, Canada's Baffin Island. With the world as their stage, the youth presented eyewitness accounts of the impacts of climate change.

Doering says experiences like these—which students worldwide can access through video, audio and other media on the GoNorth! Web site—are crucial to adventure learning. By focusing not only on environmental studies and issues, but also on the lives of Arctic students, the program takes learning out of the abstract realm and into the daily choices of each participant.

"Ultimately, the curriculum makes them aware of what's happening in the wider world and how their choices can make an impact," says Clay. "It doesn't have to be a huge thing that they do, but for instance, students here are bringing their lunch not in a paper bag but a reusable sack."

Multiplied by 3 million students, such small changes make a serious impression. In 2008, GoNorth! was named a Tech Awards Laureate by the Tech Museum of Innovation. This prestigious award is granted annually to 25 organizations or programs that use technology to benefit humanity.

"Of all the awards and recognition that I've received, that's the one that means more to me than anything else," says Doering. "These are exciting learning experiences that empower students to impact the world. Ultimately, that's the goal: To deliver an education program that can truly change the world."

JOSEPH HART is a freelance writer and editor, an author, and a longtime contributor to the *Utne Reader*, where he covers a range of topics including alternative energy and green issues. He's also a contributing writer/editor to the annual GoNorth! Curriculum and Activity Guide.

Visit polarhusky.com to learn more.

Despite its potential to trigger conflict, geoengineering will likely be part of the global response to climate change. Be prepared. **BY JAMAIS CASCIO**

The tumultuous outcome of the Copenhagen summit drives home two clear facts: The political struggles around how we respond to global climate disruption are enormously complex—and the resulting delays are bringing us dangerously close to disaster.

This disaster may not unfold in the way we expect. Accelerating changes to the global climate may render even the most aggressive carbon reductions insufficient. But there's a good chance that the action taken will be in the form of geoengineering, or the intentional modification of geophysical systems to reduce the impacts of climate change.

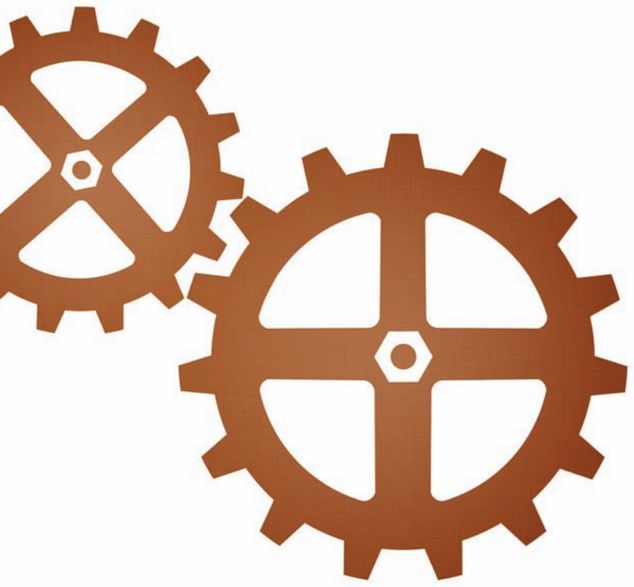
However, the clashes around geoengineering will make COP15 look amicable. Done carelessly, geoengineering could cause unintended environmental damage. It could also undermine the health and security of millions of people, and drive political wedges between powerful nations. Geoengineering could even push us to the brink of war.

While we know geoengineering would be enormously risky, we're likely to try it anyway. We can't eliminate the risks entirely, but if we act wisely, we can make the risks more manageable. Here, I lay out a few ideas for making sure that any geoengineering efforts are done in ways that reduce the risks of both environmental harm and political conflict.

RISKY BUSINESS

The idea of geoengineering has been around for some time—often imagined in science fiction and futurist tomes as giant orbiting mirrors blocking the sun. But as the dangers of global warming have become more evident, while efforts to reduce carbon emissions continued to stall, the concept has moved from the scientific fringes to the mainstream.

ILLUSTRATIONS: MARK THOBURN



Nobel Prize-winning scientists like Paul Crutzen have openly endorsed research into geoengineering—not as a substitute for carbon reductions, but as a stopgap measure to prevent runaway catastrophe. Reports from respected scientific bodies (such as the U.K.'s Royal Society and the American Meteorological Society) have cautiously endorsed research into geoengineering.

The concept is even gaining some popular visibility, appearing in *The Atlantic Monthly* and the 2009 pop-economics book *SuperFreakonomics*. It was also the focus of an article I wrote for the *Wall Street Journal*.

The current version of geoengineering has dispensed with the space mirrors, adopting a variety of more down-to-earth measures. One proposal would seed the oceans with iron to trigger algae blooms, which pull carbon dioxide from the atmosphere (initial experiments were unsuccessful, but research continues). Another would cool the atmosphere through the use of massive vortexes, mixing colder air from high up with the warmer air near the surface.

The plan that has received the most attention is one where megatons of sulfur dioxide particles would be pumped into the stratosphere, causing a slight dimming of incoming sunlight, cooling the planet by a few degrees. As outlandish as that might sound, it's an idea that has worked in nature—it's one of the side effects of a volcanic eruption.

As the most feasible geoengineering proposals do nothing about rising carbon levels, they aren't considered solutions for global warming. They're just temporary fixes meant to delay the worst heat-related impacts while the world completes its sluggish transition from fossil fuels. There are currently no known large-scale geoengineering projects underway. Yet, a growing number of scientists support the idea of researching ways to use geoengineering in a global warming crisis.

The appeal of such plans is obvious, as is the environmental risk. Nations desperate to do *something* about imminent climate disaster would readily embrace mechanisms to slow the disaster's onset. But the sheer complexity of the ocean-atmosphere system almost guarantees that interventions on this kind of scale will have unexpected and unwanted consequences.

ACTION-REACTION

We already have a few hints at what those consequences might be. One study of sulfate-injection geoengineering showed a subsequent change in global rainfall patterns, hitting the Indian subcontinent the hardest. And we know that stratospheric sulfates, natural or not, damage the ozone layer around the world.

But there's an even bigger problem arising from geoengineering: political conflict. Debates over liability, temperature targets and controlling when to start and stop would be intense. They would inevitably leave some nations or communities feeling like their concerns were ignored, or that they will bear the brunt of any negative impacts.

Both the deployment and prohibition of geoengineering would cause some nations to fear for their very survival. Areas already seeing the effects of global warming (such as low-lying island nations) may push for more aggressive geoengineering, while regions that consider higher temperatures to be beneficial may demand strict limits on it.

Moreover, geoengineering is relatively cheap, well within the budgets of smaller advanced nations or wealthy individuals (former Microsoft engineer Nathan Myhrvold's Intellectual Ventures Lab is already researching necessary hardware). International cooperation, while desirable, wouldn't be required for a geoengineering project. Desperation is a powerful driver; a decision made by one nation may not prevent another from acting in its own interest. This wouldn't just be a case of, say, the United States versus the Maldives, where one nation is significantly more powerful than the other. China and Russia, for example, could easily have different perspectives on the utility of geoengineering, and just how far it should go.

Simply put, the most fundamental driver of international politics is a nation's desire for survival. Actions perceived to threaten that survival can trigger war. And geoengineering undertaken without international consensus could threaten a number of nations' sense of security.

Nations desperate to do *something* about imminent climate disaster would readily embrace mechanisms to slow the disaster's onset.

AVOIDING DISASTER

There are some important measures that would help ensure geoengineering, if undertaken, is done in a way that would minimize harm. Even if we ultimately do not adopt geoengineering policies, these steps could provide widespread benefits:

Transparency: Decisions about geoengineering made in back-room deals, or in classified international conferences, would cause greater hostility and mistrust than would open debate and transparent decision-making. National leaders may feel unwilling to face the passing negative reactions that would emerge during public discussions. But these reactions pale in comparison to what a hidden agenda would trigger.

Transparency also applies to the information gathered during experiments, models and field work. Geoengineering would be the most ambitious and challenging global project ever attempted, and its safe deployment would demand as much analysis as we can muster. The more people we have actively studying the data and posing scientific challenges to the conclusions, the better off we'll be.

Ongoing international advisory group: The complexity of geoengineering argues for coordination of experiments, simulations and other studies intended to forecast the results of a deployment—both the environmental results and, where possible, the political implications. An international panel of scientists and social researchers should provide ongoing advice on the issues that will require greater investigation, active throughout the entire arc of geoengineering work.

A bottom-up "Ecoscientists Without Borders": Top-down bureaucracies have numerous drawbacks, so the official advisory group should be matched by a bottom-up, collaborative organization. I believe this organization should be modeled on groups like *Médecins Sans Frontières*, aka Doctors Without Borders, a non-governmental organization with a strong humanitarian perspective and clear international, *non-political*, legitimacy.

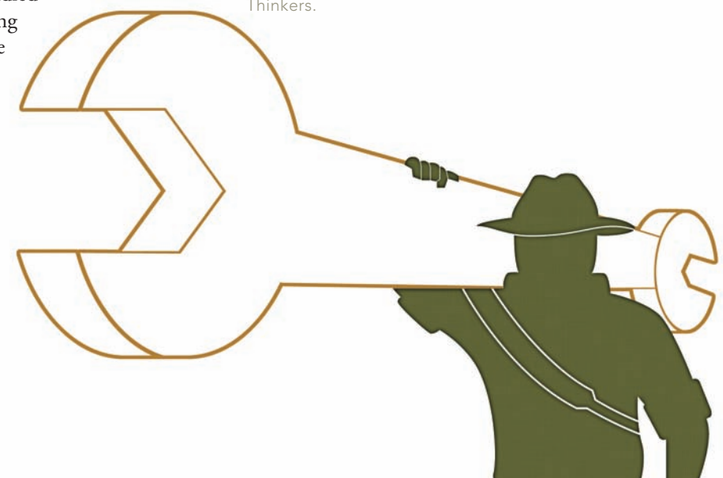
Clear mechanisms for resolving disputes: Disagreements over the impacts of geoengineering are inevitable, no matter how well-handled the deployment. One way to avoid having those disagreements turn hostile is to have established mechanisms for resolving the disputes. These could be part of the International Court, the United Nations or even a new body, as long as they are seen as having global legitimacy. One side-benefit is that these mechanisms could be applied more broadly, handling issues of environmental conflicts of all sorts, including water access and cross-border pollution.

Ban (with teeth) on non-state projects: All of these guidelines presume country-led geoengineering projects. Yet, as the Myhrvold case suggests, the cost of geoengineering is such that a wealthy individual or corporation could potentially launch a project without national support. But without even the pretense of democratic consensus, such a project would be provocative, and the country the rich individual or company calls home would still be blamed. Individual or corporate geoengineering projects not part of a government-led program should be limited to small-scale, proof-of-concept experiments. Any attempt to undertake full-scale, independent geoengineering should be met with the full force of law. Charges of "crimes against humanity" may even be warranted.

Harsh? Perhaps. But it's difficult to overstate how quickly uncoordinated, opaque and insufficiently-modeled geoengineering projects could turn catastrophic. Environmentally, the potential for unintended consequences (i.e. rapid degradation of the ozone layer, changing rainfall patterns, sterilization of parts of the ocean) is enormous. Politically, the likelihood of misinterpretation of intent, popular anger and fears of militarization is almost overdetermined.

LIKE IT OR NOT, geoengineering may be part of our response to climate change over the next decade. Protests and sternly-worded letters won't matter when a country or region is desperate to avoid environmental catastrophe. We must work to avoid the perceived need for geoengineering, while making certain that our global institutions are ready to manage such projects if and when they emerge. And we must do so soon.

JAMAIS CASCIO is a research fellow at the Institute for the Future, and the author of *Hacking the Earth: Understanding the Consequences of Geoengineering*. He has worked for more than a decade as a futurist, focusing on technology, ethics and sustainability. At the end of 2009, *Foreign Policy* magazine selected him as one of their Top 100 Global Thinkers.



CERTIFIED CONFUSION

by MELANIE WARNER

On a recent Sunday afternoon, Denise Culver stood motionless, hands on her hips, surveying the towering array of choices in the cleaning products aisle at her local Wal-Mart Supercenter in Broomfield, Colo.

A working mom with three boys, Culver wants to buy "earth-friendly" products, as she puts it. Instead, she often goes home with the "old stuff that's probably bad for you." Like millions of other consumers, Culver isn't sure if the products tagged as green really are.

And who could blame her?

On one end of the aisle, a Green Works dishwashing liquid sports both an EPA Design for the Environment seal and a Sierra Club logo. A few steps away, the Nature's Source toilet bowl cleaner assures customers it's adhering to the "Greenlist" process. And Palmolive's Eco-plus dishwasher detergent claims it's "better for lakes and streams."

"I've tried this before," says Culver, motioning toward the Scott Naturals toilet paper ("green done right") on the other side of the aisle. "But it's only 40 percent recycled, so I'm not sure if that's good."

Continued on next page…

GAME-CHANGING GREEN

When it comes to washing dishes, scrubbing the tub or doing laundry, environmentally-conscious consumers can take their pick of "green" cleaning products. But buying that non-toxic soap or free-and-clear fabric softener doesn't always mean we've made the best choice for planet Earth.

From simple solutions like vinegar and baking soda to self-cleaning countertop coatings, the eco-friendly alternatives are much broader than some product marketers might want us to believe. And this concept extends well beyond the grocery aisle.

Through her "What is a Greener Choice?" study, the University of Minnesota's Jenny Edwards aims to identify and evaluate green choices that aren't restricted to the usual either/or decisions, such as paper or plastic, organic or conventional, hybrid or gas, and chicken or beef.

"There's a lot of lively technical debate over the relative differences between Product A and Product B, but in the grand scheme of things, it may not matter so much," she says.

A fellow of the Institute on the Environment's new NorthStar Initiative for Sustainable Enterprise (NISE), Edwards is among a team of researchers trying to move beyond marginal greening efforts to more meaningful, systemic change.

This past December, thought leaders from some of the world's most progressive organizations—including 3M, General Mills, Proctor and Gamble, Medtronic, the United Nations Foundation and many others—gathered with NISE fellows and staff for the inaugural NorthStar Consortium meeting. The participants discussed potential approaches to shared business challenges in waste and pollution, freshwater access, climate, and sustainable production-consumption systems.

The results of this meeting, combined with ongoing dialogue over the next two years, are informing NISE's stakeholder-driven research agenda. The objective is to link interdisciplinary scholarship with implementing sustainable solutions in business and industry.

"This is not just another committee on corporate responsibility," explains NISE Director Tim Smith. Instead, it's a grand experiment in environmental problem-solving, with the goal of creating new knowledge that changes the game entirely.

Working together with consortium members, NISE will sponsor up to eight projects. In addition to Edward's research in "sustainable demand-side drivers," the NISE team will also investigate ways to share material and capital assets across organizations, as well as the role of private enterprise in increasing global energy and water access.

Smith says these challenges are too large for any one country, organization or individual to tackle—hence the collaborative strategy.

"It's become clear that the new century's problems require new kinds of thinking and integrated solutions," he told attendees at the NorthStar kick-off meeting. "If the private sector doesn't find ways to engage in meaningful solutions, it may lose its place at the table when it comes time to solve these problems."

Visit **environment.umn.edu/nise** to learn more.

Continued from previous page…

Recycled. Organic. Natural. Biodegradable. Non-toxic… Welcome to the murky and largely unregulated world of green marketing, in which manufacturers tag their products with a hodgepodge of highly-regarded terms.

According to Ecolabelling.org, there are nearly 90 different eco-labels in North America alone. They cover dozens of product categories and take wildly varying approaches to determining whether a product is environmentally worthy.

Standard-setting programs such as the Forest Stewardship Council, National Organic and Energy Star isolate a single component of a product's environment impact. Others take a more ambitious, life-cycle approach, seeking to measure everything from the raw materials that go into a product and the energy used to ship it to the item's eventual disposal.

While some labeling systems have rigorous, science-based standards that were developed in collaboration with reputable outside experts, others are not so picky.

"With some labels, they're just saying, 'Send me $100 and I'll give you a sticker,'" says Scot Case, executive director of EcoLogo, a third-party certification system for sustainable products run by consulting firm TerraChoice. In 2008 and 2009, TerraChoice researchers surveyed more than 2,200 products in the United States and Canada and found that more than 98 percent were guilty of "greenwashing"—in the form of everything from vagueness and irrelevance to downright fabrication.

This messy label landscape has been called a "tower of ecobabble" and a source of "green fog," generating a looming sense of disaster among many in the green marketing community. "All it takes is a few big scandals about something not being very green—after it was promoted as green—and consumers will stop trusting," says Anastasia O'Rourke, co-founder of the research firm Big Room, Inc.

Already, the Federal Trade Commission has charged four textile manufacturers with falsely claiming that their rayon clothing and other textile products are "100 percent bamboo fiber," with bamboo's antimicrobial properties. And, this past summer, the agency went after manufacturers of "biodegradable" plates, wipes and dry towels, stating that most of these products end up in landfills where they do not biodegrade.

"This issue has to be resolved before consumers just give up," says Case. "It could kill a big business opportunity."

Fortunately, efforts toward a unified authority on what's green, both for the consumer and industrial marketplaces, are now in progress. Such an über-label would be publicly available and developed in a transparent way.

A frontrunner of these efforts is Wal-Mart's Sustainability Consortium, which has convened an impressive roster of more than a dozen Fortune 500 manufacturers, as well as various environmental groups and universities.

"Wal-Mart's got the best chance of doing this because they've got the market power," says Tim Smith, director of the NorthStar Initiative for Sustainable Enterprise at the University of Minnesota's Institute on the Environment. "If they don't succeed, we're set back another 10 years. If Wal-Mart doesn't do it, no one will—the challenge being, can we live with Wal-Mart's rules?"

RECYCLED. ORGANIC. NATURAL. BIODEGRADABLE. NON-TOXIC…
WELCOME TO THE MURKY AND LARGELY UNREGULATED WORLD OF GREEN MARKETING.

Jay Golden, an assistant professor at Arizona State University's School of Sustainability and co-director of Wal-Mart's Sustainability Consortium, says the group is working on developing "a common language and a common set of rules" that companies can use for free. The resources will be available via Earthster and other open-source technology platforms to assess the environmental life-cycle impacts of their products. Rather than award labels or certifications, the consortium will let manufacturers share the results of their assessments to both retail customers and consumers as they see fit.

It's no simple task. The consortium's data will span hundreds of products, while the group evaluates a profusion of existing labels and certification programs. The goal is to decide which ones can be incorporated into the consortium's final product and which categories will need new standards.

EcoLogo's Case predicts that Golden and his team will need to create a lot of new green standards. Despite the growing ranks of green labels, there are still many categories for which no reliable assessments exist. Nobody, for instance, certifies baby products, mattresses or cell phones. Case estimates that existing eco-labels cover only 10 percent of product categories. He says EcoLogo, which certifies everything from paints to cleaning and paper products, is just now developing standards for toys.

Another Herculean challenge facing the Sustainability Consortium is actually convincing manufacturers to adopt new sets of environmental rules and standards. Across the consumer landscape, manufacturers have largely shunned third-party, life-cycle-based labels, embracing only a few single-attribute programs like Energy Star and Fair Trade. Most companies have opted to fashion their own criteria.

"Companies often feel that using a third-party certifier like ourselves borders on regulation, so there's a lot of hesitation and backlash," says Linda Chipperfield, vice president of marketing and outreach at Green Seal. "They want their own brand to be the one that's known as green."

This widespread reluctance is understandable. Research shows that most consumers don't distinguish between products that have gone through an actual certification and those where the manufacturer decided to slap a few trees on the packaging and call it earth-friendly.

Initially, the Sustainability Consortium's efforts could create more confusion before they do any good. The group's first initiative, a standard for green electronics, will eclipse much of the work of the Electronic Product Environmental Assessment Tool (EPEAT). EPEAT, which has been successful among government and industrial buyers, is now making progress in the consumer marketplace. Currently, Buy.com, Best Buy for Business and TechDepot identify EPEAT-qualified products on their Web portals, with more retailers to come.

So, in some areas, the Sustainability Consortium may be trying to reinvent the wheel, says EPEAT Executive Director Jeff Omelchuck. "Lots of people have worked to develop these standards. If they wanted to they could use EPEAT for free, so it makes some of us wonder why they don't."

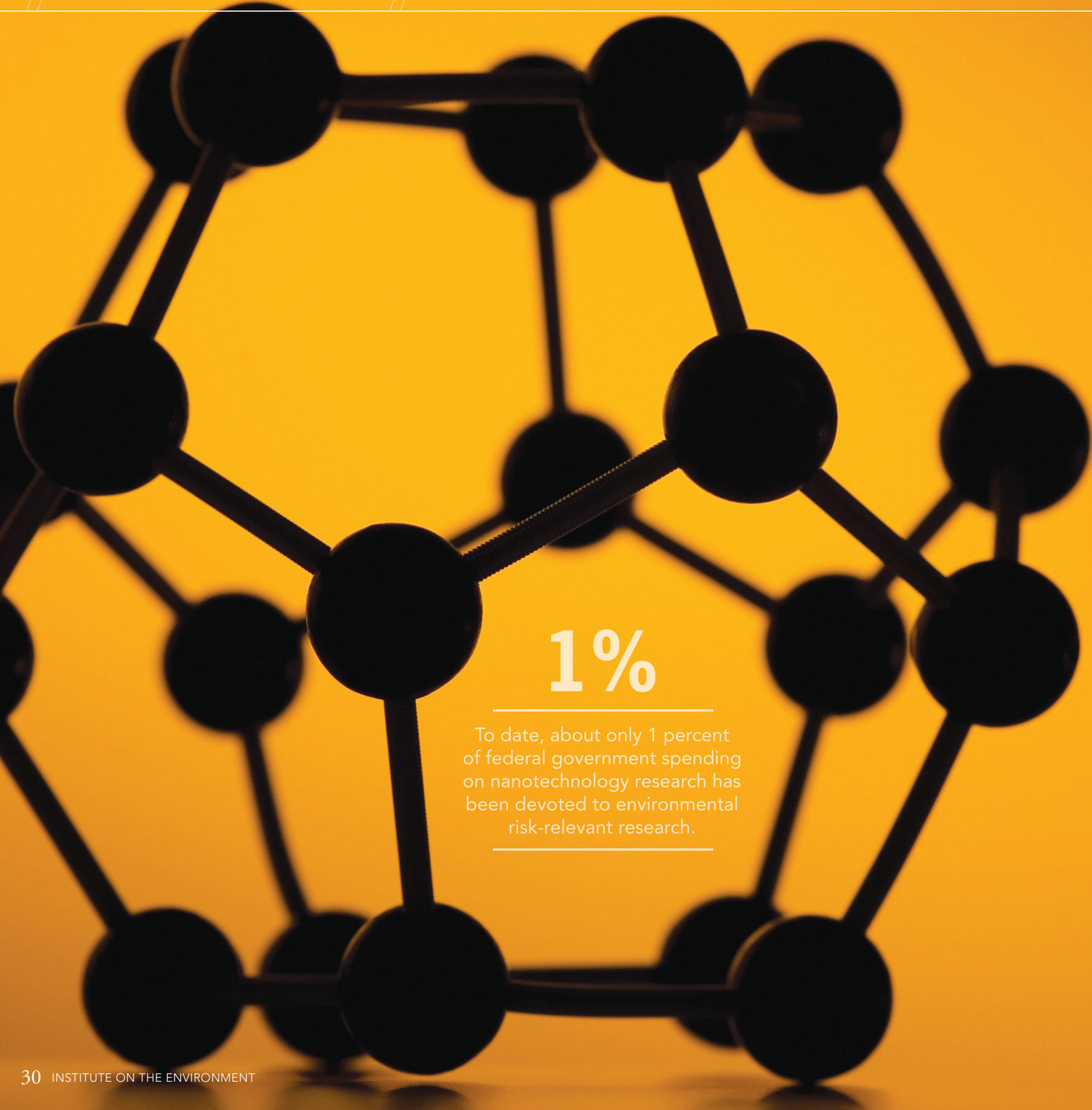
Golden says the Sustainability Consortium's electronics standard will incorporate EPEAT, but will go beyond it to include things like the labor conditions under which computers are manufactured.

The good news: There's an unprecedented awareness that the eco-label problem needs to be fixed. The Keystone Center, a non-profit headquartered in Keystone, Colo., has convened a roundtable of manufacturers, trade associations, environmental groups and certifiers to look at how the cacophony of labels can be harmonized. And the David and Lucile Packard Foundation is underwriting an extensive study that will assess how much green standards like the Marine Stewardship Council and Fair Trade are impacting both consumer buying patterns and producer practices.

The not-so-good news: It's going to take several years before we reach a productive conclusion. "It's a long haul, but I'm confident it will get sorted out," says Big Room's O'Rourke.

Until then, shoppers like Denise Culver will have to proceed through the fog with caution. Let's hope a standard emerges before green fatigue sets in.

MELANIE WARNER is a Boulder, Colo.-based freelance writer who covers food, the environment and green business. Her articles have appeared in *The New York Times*, *Fast Company* and *Business 2.0*, among other print and Web publications.



1%

To date, about only 1 percent of federal government spending on nanotechnology research has been devoted to environmental risk-relevant research.

Nanotech: A History Lesson

Tighter regulation of nanotechnology could keep us from learning the hard way once again.

by JENNIFER KUZMA

We're living in a chemical soup, exposed to multiple hazards that we cannot see, hear or feel. Ecosystems are also suffering from this recipe of human-made materials. Historically, our response to chemical hazards—whether as ingredients or mixtures—has been slow at best.

It took 30-plus years to ban DDT since its first use as a pesticide. And pollution continues to seep into the water from the Bhopal disaster, which happened more than a quarter-century ago at a pesticide plant in India. Lawsuits associated with that tragedy are still pending.

Lack of political will, economic agendas, and uncertainties over environmental risk assessment are among the challenges to addressing environmental pollution before it's too late. Now, history seems to be repeating itself with the newest addition to the soup mix: engineered nanomaterials (ENMs).

Nanotechnology involves the manipulation of matter at the atomic scale, 1 to 100 nanometers (1 billionth of a meter), to create new products and processes with novel properties. It's being used in material engineering, consumer products, food production, agriculture, health care, environmental remediation and medicine.

Many portray nanotechnology as today's greatest revolutionary force. More than a thousand consumer products currently on the market contain nanomaterials, from dental fillers, fuel cells and tires to electronics, clothing and cosmetics. Nanotechnology could help improve human drugs, pesticide delivery, renewable energy systems, and the quality and safety of food.

At the nanoscale, matter takes on increased reactivity, unique electrical and physical properties, and the ability to penetrate biological and environmental systems. Some of these properties can be harnessed for environmental benefit. Superfund sites, where hazardous waste is located, are being remediated with iron nanoparticles. In addition, solar cells developed with ENMs are proving to be more efficient with the use of fewer materials.

However, these special properties also allow nanoparticles to cross the blood-brain barrier in the central nervous system, among other physical separations in organisms. And nano-versions of existing chemicals are more toxic to animals at lower concentrations than their larger cousins.

In other words, nanotechnology presents a double-edged sword. While it has potential to benefit society, it also has potential to increase risk.

The United States has yet to see a coordinated approach to environmental regulation of ENMs, even though their manufacturing, use and disposal have occurred for more than a decade. Our laws and regulatory processes are not designed to capture nano-versions of existing products. Moreover, there's little information on where nanomaterials are produced or in what quantities. No mandatory reporting requirements exist. There is also little pre-market testing for the ENMs used in most products.

Washing machines with silver nanoparticles illustrate just one crack in the regulatory system. The machines allow clothes to last longer without smelling (i.e. bacterial growth is prevented by the particles), but the associated ENMs end up in surface and ground water—despite the fact that their toxicity to microorganisms has already been established.

After intense pressure from non-governmental organizations, the U.S. Environmental Protection Agency is just now starting to consider the regulation of silver ENMs as pesticides. But if the manufacturer does not claim that the product is a pesticide, the regulatory process is not triggered. For example, some silver ENM products are now marketed as "fresher longer" instead of germ-killing.

To date, about only 1 percent of federal government spending on nanotechnology research has been devoted to environmental risk-relevant research. A new bill to increase this percentage has been drafted, but has yet to pass the House and Senate.

At the same time, laboratory studies on the toxicity of ENMs to several indicator organisms are accumulating. Bans on the most toxic ENMs, such as certain carbon nanotubes with asbestos-like properties, should be considered until more studies are gathered and interpreted.

These bans may not be purely "science-based" decisions, in the sense that the damage hasn't been explicitly seen, at least not yet. Considering our history of chemical usage and environmental impacts, a cautious approach makes sense. Given its "newness," nanotechnology presents an opportunity for us to do better this time.

JENNIFER KUZMA is an associate professor and area chair of science, technology and environmental policy with the University of Minnesota's Humphrey Institute of Public Affairs. As a resident fellow of the Institute on the Environment, she's researching the risks and benefits of nanotechnology to determine how social and policy variables can maximize benefits while mitigating risks.

Heated Exchange

University of Minnesota researchers aim to build up geothermal's potential by pushing down CO_2.

by JESSICA MARSHALL

Martin Saar suggests a trade: Let's bring heat up from Earth's depths to make electricity and, in return, we can stuff a bunch of climate-changing carbon dioxide back down below.

Combining geothermal energy extraction with carbon storage could be a win-win for clean energy. Geothermal projects would become more efficient when CO_2, rather than water, is used to carry heat. At the same time, greenhouse gas emissions could be stored deep underground where they can't heat up the climate. Merging energy recovery and carbon storage in a single site improves the bottom line for both.

PHOTOS: JOSH KOHANEK

High-temperature, high-pressure carbon dioxide is almost twice as efficient as water for collecting geothermal heat.

Saar, a geoscientist at the University of Minnesota, and graduate student Jimmy Randolph were driving north from the Twin Cities to Bemidji to conduct hydrogeology field work, when they had the "aha" moment that sent them down this research path. "We discussed the idea for several hours in the car," Saar recalls.

A standard geothermal electricity project pumps water to raise heat from up to a mile or more underground. But as it turns out, high-temperature, high-pressure carbon dioxide—in a "supercritical" state, where it acts partially like a liquid and partially like a gas—is almost twice as efficient as water for collecting geothermal heat in these systems.

Meanwhile, researchers worldwide are trying to figure out how to bury fossil-fuel-generated CO_2 permanently underground as a strategy for combating climate change. This approach raises a number of concerns, especially how to make sure the CO_2 doesn't leak out.

Nevertheless, Saar believes the time required to transition from fossil fuels to renewable energy makes carbon sequestration inevitable in the face of climate change. And sites composed of porous rock beneath an impermeable cap layer, far from drinkable groundwater, provide the right conditions for storing carbon dioxide.

Saar and Randolph's idea is to choose sequestration sites that also have accessible geothermal energy—places where heat flow from the planet's interior is significant enough to be captured and converted. While the majority of the CO_2 that gets sent underground would be permanently stored in a geologic formation, a fraction could rise back up, carrying sufficient heat to generate electricity in a turbine. After passing through the turbine, the cooled CO_2 would be reinjected, thus eliminating its release into the atmosphere.

The gains in efficiency from using carbon dioxide instead of water could make geothermal projects more feasible, says Saar. Shallower depths or lower temperatures might be hot enough to justify energy extraction, especially if CO_2 sequestration was going to happen at the site anyway.

One big question remains, says Saar. "'How hot does it really need to be?' It looks like it doesn't have to be as hot as with water because of the efficiency improvements, but it's still true that the hotter, the better."

Saar and Randolph are also trying to determine how deep the sites need to be and whether the CO_2 would react with rocks to clog things up or dissolve away the underground minerals.

Despite the challenges, Saar says geothermal energy has many advantages compared with other renewable energy sources. No complicated or expensive energy storage system is required, since geothermal power plants can be turned on and off quickly. As a result, geothermal energy can provide peak electricity while also meeting the baseload demand—because, unlike solar or wind, Earth's heat is on hand 24/7.

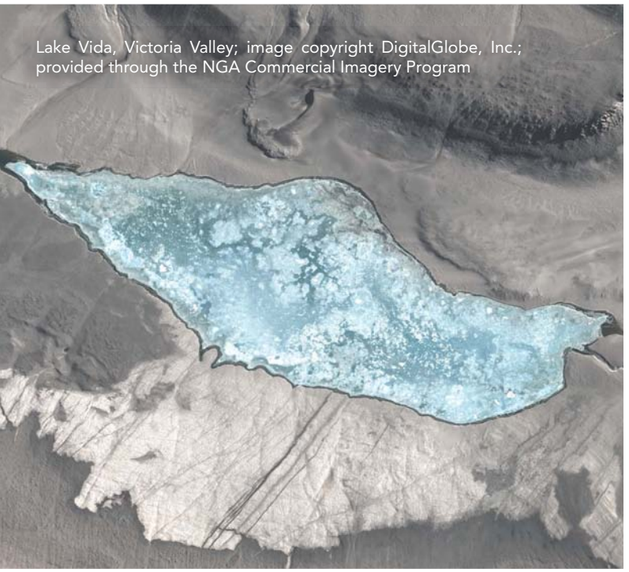
Saar's project is supported in part by the Initiative for Renewable Energy and the Environment, an IonE signature program. Visit **environment.umn.edu/iree** *to learn more about IREE-funded research.*

JESSICA MARSHALL is a St. Paul, Minn.-based science and environmental journalist, and the environment correspondent for *Discovery News*.

Charting the Frozen Continent

Thanks to the Antarctic Geospatial Information Center, scientists have a picture-perfect view of life in the very deep south.

by MAGGIE KOERTH-BAKER



Lake Vida, Victoria Valley; image copyright DigitalGlobe, Inc.; provided through the NGA Commercial Imagery Program

It's January, and bitterly cold in Minneapolis. This time of year, there aren't many places you can call up and gloat about Minnesota weather, but Antarctica really ought to be one of them.

"Oh, it's 32 and sunny here," says Claire Porter, a University of Minnesota graduate student working on the ostensibly frozen continent. "We spent the whole day outside hiking and playing around."

Antarctica, as it turns out, defies all sorts of expectations. Far from a blank, white canvas, the bottom of the world is a beautiful place, full of breathtaking peaks and stark, rock-strewn valleys studded with cerulean lakes. But the things that make Antarctica so fascinating—and such an important center for scientific research—also make it a difficult place to work. Porter is part of a team of scientists whose job is to make other scientists' jobs easier.

From tracking penguins and mapping unique geological features, to making sure satellite Internet connections aren't blocked by an inconvenient mountain, the Antarctic Geospatial Information Center has a finger in just about every research pot. Amazingly, it does all this on a budget of less than $500,000 a year, and a staff of only 10, most of them graduate students.

Paul Morin, the center's director, came from the world of data visualization—he's written textbooks, worked with science museums and helped the National Center for Earth-surface Dynamics better understand changes in river system ecology. He started the AGIC two years ago.

"Our grant is to provide geospatial support for the U.S. Antarctic research program. The majority of people down there need help with geographic information systems, cartography, remote sensing or some kind of analysis," he says. "A lot of this is mapping, and mapping is just a form of visualization."

While the big picture was familiar territory for Morin, the details of working—and even, for short stretches, living—in Antarctica have been a very different experience. In mid-December, he was about to set off on his third trip to Antarctica. He stays about a month each time. Going to the continent with the National Science Foundation is a lot like going to space with NASA, he says: You basically show up with your computer and some clean underpants, and the rest is taken care of.

The NSF sends Morin and his team plane tickets to New Zealand, issues cold-weather clothes, shuttles them to Antarctica in a military C-17 transport and outfits them on arrival. "Everybody needs gear down there and not everybody is from Minnesota," he says. "They have a facility in Antarctica called the Berg Field Center, and it's basically REI. You go in and you say, 'I need this tent, I need this food,' and they know everything about it."

Thanks to that system, Morin and his team are left without much to worry about besides their work. That's good, because supporting almost all the research in Antarctica is a time-consuming task, which can even take the AGIC team outside the heated, catered confines of McMurdo Station and into the Antarctic frontier.

This year, Morin and his crew were preparing to camp in Antarctica's McMurdo Dry Valleys—a place that serves as an analog for Mars on Earth. As the name implies, there's little snow in the dry valleys. There's also very little life, just cyanobacteria and the occasional seal that wandered in and died.

"The highest form of life in these places is nematodes," says Morin.

AGIC is going there for several reasons. First, they'll set GPS points and match them to their maps and huge database of satellite images, so researchers will have a more accurate understanding of just where it is they're looking at. Along the way, they'll also map the rare wet patches in these valleys—such as Don Juan Pond, the saltiest lake in the world. That information will help scientists who study extreme forms of life know where to look for them.

But not all their work is in the field. Recently, AGIC was given access to images of Antarctica, taken by the same satellites that do intelligence imaging for the U.S. government.

Southern Bull Pass, McMurdo Dry Valleys; image copyright DigitalGlobe, Inc.; provided through the NGA Commercial Imagery Program

Inset: Morin's camp at Bull Pass; photo by Ziggy Malolepszy

"Because the orbits of these satellites come together at the poles, I can shoot every point in Antarctica up to three times per day, per satellite," Morin says. "There's no competition because nobody using them wants to see Antarctica but me. And each pixel is between 50 centimeters and 1 meter. I'm getting between 200 and 500 gigabytes of data every day."

The images are in exquisite detail. The hard part is figuring out how to organize, store and actually put the information to productive use. It's an overwhelming task, but Morin and his team are starting to get the hang of it. One of the ways they've used the images is to help penguin researchers find colonies of the birds and track their movements.

How do you find penguins on a satellite image? "Even with this level of detail, it's hard to spot the birds," says Morin. "So what we do is look for reddish-brown smears on the snow—trails of penguin poop—and follow those back to the colonies, which you can see because it's just a huge spot of poop."

MAGGIE KOERTH-BAKER is a Minneapolis-based science and health writer whose work appears regularly in *mental-floss*, *Discover*, *Audubon* and many other national magazines. She's also a contributing editor to the award-winning blog, BoingBoing.net.

The New Environmentalism

by TODD REUBOLD

Times are tough for environmentalists. The movement that brought us clean water, the Endangered Species Act and Al Gore is witnessing the inconvenient truth of runaway greenhouse gas emissions, increasing biodiversity loss and the decline of ocean life. • As a new decade dawns, can the environmental movement regain its shine (and significance)? To find out, *Momentum* asked a leader from one of the nation's most influential environmental action groups, along with the guy who literally wrote the book on reinventing environmentalism.

"Over the past 10 years, more policy work and direct negotiation with industry has been a hallmark of the environmental movement. I think we'll see even more of that in the future. Using the NRDC as an example, so much of what we're doing is trying to change the way people do business. Outside of our accounting department, we didn't have a single M.B.A. on staff until maybe five years ago. Now we have a whole group of people who come from business and understand how businesspeople think about these issues.

Everybody wants clean water. Everybody wants clean air. Nobody wants their children to live next to a toxic waste dump. The underlying values are shared. Where we don't agree is not in the end result. Rather, it's the tools we use to get there. So, what's the balance between government regulation and letting the market decide? If you define environmentalism as long-term thinking and an enlightened self-interest, I think most people would say, 'Yes, I care about these things.' But what does that mean in practice? There's never been unanimity within the environmental community about the tools.

If you look at the numbers for who wants clean energy, and who wants to wean us off foreign oil or oil altogether—those numbers are huge. It depends so much on how you frame the question to people. If you define our goal in a way that's understandable to regular people who aren't inside the beltway negotiating the nitty-gritty details of legislation, I think there's a huge commonality of interest, purpose and support for all the core things we're trying to achieve.

I'm hugely optimistic [about the environmental movement]. We have no choice but to solve these problems, so we're going to solve them."

DALE BRYK
Air & Energy Program Director
Natural Resources Defense Council

"The argument we made [in "The Death of Environmentalism"] is even more right today than it was in 2004. Unfortunately, when *An Inconvenient Truth* happened, we had a moment of mania among greens. Mostly they were talking to each other, but they convinced themselves that everyone had seen the light.

There are fundamental technological and economic obstacles to capping, regulating or pricing our way to a clean-energy economy. The scale of transformation necessary to achieve significant reductions is much wider than anyone imagined. The politics are going to work only when we acknowledge that it's a technological challenge, and put technology and innovation at the center of the political agenda.

We [co-author Michael Shellenberger and I] have been incorrectly identified as technological optimists. In fact, we're technological pessimists, at least when it comes to existing technology. … But we're optimistic that when we understand it's a technology and engineering challenge—not an economic or a regulatory challenge—we can identify a set of technologies and develop them sufficiently to do the things we need them to do.

I was born and raised in the environmental movement and spent many years working for the biggest environmental groups. So I had a strong environmental identity all of my life. I would describe myself now as a post-environmentalist. Post-environmentalism is what happens when we move old ideas about the environment out of the center of our basic political and philosophical proposition. If the environment doesn't include humans, then it's a scientifically unsound concept. And if it does include us, it becomes another synonym for everything. In post-environmentalism, ideas of nature and things being natural versus unnatural just go away.

The real question is: What environment do we want to live in? And that will be something we create."

TED NORDHAUS
Chairman, The Breakthrough Institute

Co-author, *Break Through: From the Death of Environmentalism to the Politics of Possibility*

INSTITUTE ON THE
ENVIRONMENT

UNIVERSITY OF MINNESOTA
Driven to Discover℠
1954 Buford Ave. • 325 VoTech Bldg.
St. Paul, MN 55108

Nonprofit Org.
U.S. Postage
PAID
Minneapolis, MN
Permit No. 155