

## Hearth Health: Cooking Up A Safer Way To Prepare Meals

Colorado State University



Every day, millions of people around the world engage in an essential task: preparing meals for themselves and their families. It's a life-sustaining endeavor, but cooking can also pose life-threatening problems. That's because nearly half the world's population cooks over fires that use wood, charcoal and other biomass for fuel, according to the Global Alliance for Clean Cookstoves. As a result, they are exposed to carbon monoxide, black carbon and a host of other toxins.

The Envirofit G3300 Clean Cookstove, currently sold in more than 40 countries, helps eliminate those risks. Thanks to innovative engineering, it not only dramatically reduces the smoke and harmful gasses emitted by cookstoves, but also uses less fuel and reduces cooking times — which leads to wide-ranging benefits for personal safety, climate change and more.

An Under-the-Radar Threat Despite the severity — and enormity — of health problems surrounding traditional

cookstoves and open-flame cooking, the issue largely remains outside the public consciousness. Consider that smoke inhalation from cooking may cause nearly 2 million deaths annually, according to the World Health Organization. That's more than double the deaths caused by malaria each year. The medical fallout includes pneumonia, chronic respiratory disease, heart disease, low birth weight and tuberculosis — and the resulting premature deaths mainly affect women and children. It's not an issue that will disappear anytime soon, since this cooking method proliferates in developing nations that also have steady population growth.

What's more, it's an insidious problem. People who use open-flame cooking often don't recognize any health risks in their meal preparation. "Their mother did it that way, and their grandmother and their grandmother's grandmother," says Nathan Lorenz, M.Sc., vice-president of engineering for Envirofit International. That deeply ingrained seal-of-approval is tough to discredit. When asked if they've ever felt faint or dizzy while using open-flame cooking, people will say yes — but blame it on not eating enough that day, says Lorenz: "Actually, it was most likely carbon monoxide inhalation."

## **Shifting Gears**

Cookstoves weren't part of Envirofit's original plan. Instead, the Fort Collins, Colo.-based nonprofit aimed to reduce pollution from two-stroke motorcycle engines. It was founded in 2003 by two students and two professors from Colorado State University: Lorenz and Timothy Bauer, M.Sc., both mechanical-engineering graduate students at the time; entrepreneurship instructor Paul Hudnut; and Bryan Willson, Ph.D., director of the university's Engines and Energy Conversion Laboratory.

Envirofit's initial mission emerged from one of Lorenz and Bauer's student projects, where they successfully created a cleaner engine for the pollution-spewing two-stroke engine found in snowmobiles. But snowmobiles had scant market potential, so Envirofit focused on retrofitting two-stroke engines of motorcycles (used mainly in India and Southeast Asia) to reduce emissions.

The focus shifted in 2007 after Envirofit met with the Shell Foundation, the charity arm of Shell Oil, to seek funding assistance. As it turned out, Shell Foundation didn't have much money to bolster nonprofits tackling transportation issues. But it did have a funding program for indoor air pollution initiatives. During the meeting, Shell posed an unexpected question for Envirofit: Did they have any experience with cookstoves?

Thanks to a bit of serendipity, they did. During graduate school, Lorenz and Bauer helped test cookstove emissions in a CSU lab. They worked alongside Morgan DeFoort, Ph.D., now co-director of the Engines and Energy Conversion Lab at Colorado State University. Although Lorenz and Bauer (now Envirofit's vice president of operations) had cookstove experience, they didn't have all the answers. With funding from Shell Foundation, Envirofit needed help designing a safer, affordable cookstove. For that, they turned to DeFoort and his colleagues at the university's Engines and Energy Conversion Lab.

## **The Path to Cleaner Combustion**

On the face of it, cookstove design seems like a simple problem for someone with a doctorate in engineering. DeFoort quickly learned that wasn't the case. "It's a humbling problem," he says. "The cookstove is actually incredibly complex from a combustion standpoint, much more so than an engine is." That's due, in part, to the cookstove's fuel source.

Take wood, for example. “Wood is a mixture of all sorts of chemicals, so when you burn them, there’s a much more complex reaction,” says DeFoort. “It’s this open-ended, multivariable kind of problem, which makes optimizing it very difficult.”

As Envirofit worked toward that optimization, they wanted to avoid repeating the mistakes of others. One problem with previous cookstove initiatives, says Lorenz, is that they often emphasize a social mission over pollution reduction — specifically, the stoves needed to be produced locally. But those good intentions can bring unintended consequences.

“You get such horrible quality control when you do those kinds of programs, and you end up sacrificing the indoor air pollution goal by focusing too much on how and where it’s built,” says Lorenz. He’s seen many cases where local people learn to build cookstoves — and a year or two later, the cookstoves they produce bear little resemblance to the original design. “People didn’t like certain features, so they changed them,” says Lorenz. In the process, they unwittingly remove the design elements that had improved the stove’s emissions.

To ensure rigorous quality control, Envirofit chose to mass-produce the stoves in a factory. But that doesn’t mean they’re not helping local economies. Instead of selling direct to end users, Envirofit sells stoves to distributors, who hire local retail agents. “It’s hard to put a number on it, but there definitely has been a lot of job creation across these countries in the sales and distribution areas,” says Lorenz.

Mass production meant Envirofit would have to ship the stoves, which posed its own set of challenges. Typically, cookstoves have ceramic or clay combustion chambers, making them ill-suited for shipping because those materials are heavy and breakable. And Envirofit wanted a durable cookstove—one that would last at least five years.

The design team decided that the best solution would be an all-metal combustion chamber. But to do that, they needed the right alloy. “You think of a cookstove as a very simple thing that you build fire in, but it’s actually an incredible harsh environment for any metal to live in,” says Lorenz. The material would need to withstand temperatures up to 1,650 Fahrenheit and exposure to corrosive compounds released when biomass burns.

DeFoort and his colleagues knew that such metals existed. They’re called super alloys — but at about \$50 per pound, they carry a super-big price tag. Envirofit needed a metal that would be less than 10 percent of that cost. To make any in-roads replacing open-flame cooking methods, the product had to be inexpensive. As Jeremy Nelson, licensing and business development director at CSU’s technology transfer office observes: “Your competition is three rocks on the ground.”

To develop a special alloy that was both resilient and inexpensive, the design team worked with the Oakridge National Research Laboratory, which has a group focused on high-temperature materials. After a year of testing an array of metals, they found a low-cost option that could survive a cookstove’s punishing interior.

That breakthrough opened up possibilities that hadn’t existed for other cookstoves. “Once we had the metal, we could do some interesting things on the design side,” says DeFoort. That includes making the stove more lightweight, which reduced the amount of fuel needed. The designers also added an orifice ring — a round metal plate with hole in the middle, like a large washer. It helps recirculate the gas to the center of the combustion chamber, increasing the chance

that it will be fully combusted, and that means reduced emissions. “It’s a very simple thing,” says DeFoort. “But nobody had thought of it because nobody could use metal in a cookstove before.”

Those changes helped lead to a cookstove that emits up to 80 percent less smoke and harmful gasses, uses 60 percent less fuel, and reduces cooking times by 40 percent.

The inventors—Morgan DeFoort, Ph.D., Bryan Willson, Ph.D., Nathan Lorenz, M.Sc., Anthony Marchese, Ph.D., Michael P. Brady, Ph.D., and Daniel D. Miller-Lionberg—saw the result of their work in 2008, when the Envirofit G3300 Clean Cookstove entered production.

In May 2009, CSU Ventures (the university’s technology transfer office) licensed the technology to Envirofit. Since the cookstove initiative began, CSU Ventures has emphasized flexibility while working with Envirofit, as the nonprofit seeks to overcome supply chain difficulties in overseas markets that aren’t necessarily easy to penetrate, says Jeremy Nelson, Ph.D., licensing and business development director. “We’re doing a lot of support coordinating the office actions and the patent applications,” he says. Currently, there are two patents pending on the cookstove design.

“We have a pretty progressive tech transfer office here at CSU, and they did a very nice job of shepherding the relationship,” says DeFoort, who describes CSU Ventures as very supportive. “They let Envirofit have a seat at the table as we sorted out the IP [intellectual property] and decided what was worth patenting and what wasn’t,” he says.

Envirofit began marketing its product in India, and by 2010, it started distributing in Africa and then Latin America. The core technology from the G3300 Clean Cookstove is now used in five other Envirofit wood and charcoal stoves. So far, the nonprofit has sold more than 350,000 clean cookstoves around the world.

### **The Ripple Effect of Optimized Stoves**

United Nations Foundation President Timothy E. Wirth notes that cooking conditions represents the fifth greatest threat to health in poor developing countries. By building a better stove, DeFoort, Lorenz and their colleagues help ameliorate risk factors that extend beyond the detrimental effects of inhaling smoke and toxic gasses every day.

When cookstoves use less fuel, for instance, it leads to multiple benefits in health and well-being. Women and children do most of the fuel gathering — and often, that takes place in conflict areas, exposing them to violence. If they don’t have to collect as much fuel, they spend less time in harm’s way. And there are additional benefits for children, who can spend several hours a day collecting fuel. “If the children only have to gather half as much, then that’s more time they can spend studying and being kids,” says Lorenz.

For those who buy fuel instead of collecting it, the optimized cookstove can help save a substantial amount of money. In some areas, up to 40 percent of the household income is spent on fuel for cooking, says Lorenz. When people pay for fuel versus gathering, they instantly recognize the value of the stove, because they can put a dollar amount on using half as much wood, he says: “Some people say they use 80 percent less fuel with the stove.”

The stove offers environmental benefits too. By requiring less wood, it reduces deforestation. And when it does burn biomass, it does so thoroughly. That’s important, because incomplete combustion spits out pollutants like black carbon

and methane that go into the atmosphere.

“*They’re actually much more harmful from a global warming standpoint than carbon dioxide,*”  
says DeFoort.

Recently, the need for safe, affordable cooking has gained some much-needed attention. In 2010, the Global Alliance for Clean Cookstoves was formed, with Colorado State University and Envirofit as founding members. Led by the United Nations Foundation, it’s a public-private partnership of more than 60 national governments, UN agencies, private companies and nongovernmental organizations, all working toward a clean efficient approach to cooking (actress Julia Roberts signed on in 2011 as a global ambassador for the alliance).

Still, DeFoort knows a disconnect still exists between the developed world’s kitchen, and the rest of the world. “When I give people tours of our lab, I show them the stove and I say, ‘We’re in the minority. Most of the world fires up a stove and cooks inside their home and breathes a bunch of smoke,’” says DeFoort. “And I think that really surprises people.”

With Envirofit’s cookstoves, there’s now a safer way to prepare meals — and a recipe for better health.

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