The WONDERS of WOOD

UMaine's **Hemant Pendse** is using Maine's most prevalent natural resource to try to change the world's energy future. So far, so good. BY HENRY GARFIELD

Hemant Pendse doesn't just see the forest for the trees. Pendse, the chair of the Department of Chemical and Biological Engineering at the University of Maine in Orono and director of the Forest Bioproducts Research Initiative, looks for new ways to use those trees as a source of fuel. And he wants to do this by using parts of a tree that the pulp and paper industry leaves behind.

Using a process pioneered by his UMaine colleague Professor Adriaan van Heiningen, Pendse and his team extract hemicellulose-based sugars from wood chips bound for pulping. The pulping process has been shown to be unaffected by the process and produces the same quality pulp. Meanwhile, the extracted sugars can be made into profitable biofuels and other high value by-products with the potential to change Maine's—and the world's—energy future.

Started in 2004, the Forest Bioproducts Research Initiative (FBRI) is ready to move from test tubes to testing ground. The former Georgia Pacific paper mill in Old Town, under new management and a new name (Old Town Fuel and Fiber), reopened last year and is actively involved with the university in the production of new biofuels. Plans are in the works for a new technology center in an existing building on the mill property, and ground will be broken this year on an addition to Jenness Hall on campus that will house FBRI offices.

Pendse is originally from Mumbai, India. He earned his PhD in chemical engineering from Syracuse University and has been at the University of Maine since 1979. He recently sat down with *Bangor Metro* to discuss his work and what it could mean for the future of the nation's most heavily forested state.

What is the Forest Bioproducts Research Initiative?

Maine's wood extracts are going to play a significant role in our country's energy future. The Forest Bioproducts Research Initiative Technology Center is made up of chemical engineers, pulp and paper technologists, folks who work in wood composites, and foresters, and will become a one-stop shopping place for anyone dealing with woody biomass anywhere in the world.

How does the extraction process work?

We extract part of the wood but still protect the fiber, so people can get pulp out of it. Essentially, the part we are taking

Hemant Pendse at the FBRI lab on the University of Maine campus.

The first part of the extraction process works like a coffeemaker. Water and chemicals are poured through hardwood chips, producing a brown-colored liquid while preserving the part of the wood used to make pulp.

out would have been burned—it would have been used to make steam. We can get much higher value than if they burn it. We think that we can eventually make jet fuel out of it.

The University of Maine has a unique technology. In simple terms, think about it like your coffeemaker at home. You have coffee grounds, you put hot water on them, and you see brown-colored liquid coming down—that's extraction. We do something similar with wood chips, but instead of just pouring hot water over them, we work at very high temperatures and high pressures, and the liquid has some chemicals in it. But essentially what it does is remove material from the wood that comes out in brown-colored liquid that we call our pre-extract, and that's the source of the sugars that we talk about. That liquid [called black liquor] can be fermented to make ethanol or butanol or other products, including precursors to bioplastics. These sugars would have been otherwise burned in a pulp mill.

The key is that we do it in a controlled and selective way so we don't damage the cellulose fiber—that fiber is what mills use to make pulp.

How does the mill in Old Town figure into this?

We have created a demonstration project at the Old Town mill that will show our ability to convert an old pulp mill into a fuels and chemicals facility. They call it demonstration because a full-scale facility would be much larger. The mill is supported by the U.S. Department of Energy with a $30 million grant to convert wood into fuels and chemicals.

A working pulp mill handles 1,200 metric tons per day of dry wood. The extracted sugar part of that will be under 10%. That's taking less than 10% of wood material out as sugar in this pre-pulping extraction and doing something else with it.

Eventually, the mill will be generating more than a million gallons of liquid transportation fuel per year, plus a chemical called acetic acid, which is used in the food industry like a vinegar used to flavor french fries.

So from the same biological source you're going to get food products and jet fuel?

Exactly. They are complementary but different revenue streams. It will be a regular manufacturing facility, producing a million to a million-and-half gallons per year of advanced cellulosic fuel, and a similar amount of acetic acid.

How far away is this from being commercially viable?

Right now we are in the phase one portion where we are doing the design of the biorefinery add-on facility. Once that design is ready for construction, businesspeople will make the decision to proceed due to the large commitment of money a project like this requires. But with the new $30 million grant, the DOE pays to help with construction. That grant has a one-to-one

match. That means that for every dollar from the government, the private sector has to put one dollar in. When that financial commitment is made, then it will probably take 18 months to build and construct the biorefinery. If you assume six more months to make sure the start-up and everything goes well, in 24 months we would be producing new biofuels right here in Old Town.

"There are a few other places working on algae as a source, but on wood-based jet fuel, I think we are in the lead." –Hemant Pendse

The university faculty works very closely with the mill. They have already deployed the pre-pulping extraction technology on a commercial scale. Wood chips are going through this pre-extraction vessel continuously. This mill-scale deployment is what makes the Old Town mill unique. It's the only place in the world where, from this kind of pulp mill, we are getting this pre-extract.

Liquid fuels and bioplastics already have existing markets. We will be creating a product using a renewable source rather than using petroleum. Once the product is made, it goes to market.

What will the new technology center do?

It will be used by forest product companies, chemical companies, energy sector companies, and new start-ups that are coming up with new technologies. They will rent it for a length of time, pay for the costs of the research they do, collect the data, and go home and analyze it.

There are people waiting in line right now to pay for the service. Large corporations will come to us, because we have all the operations in one place, and they will be able to get some preliminary data. We are changing the way wood is used.

We have the ability to predict the flow of the wood and biomass in the forest, bring in new technologies that will enable us to get higher value out of the wood, and also find new opportunities that will benefit forest landowners and the existing forest products industry.

What are some of the challenges involved in making these fuels?

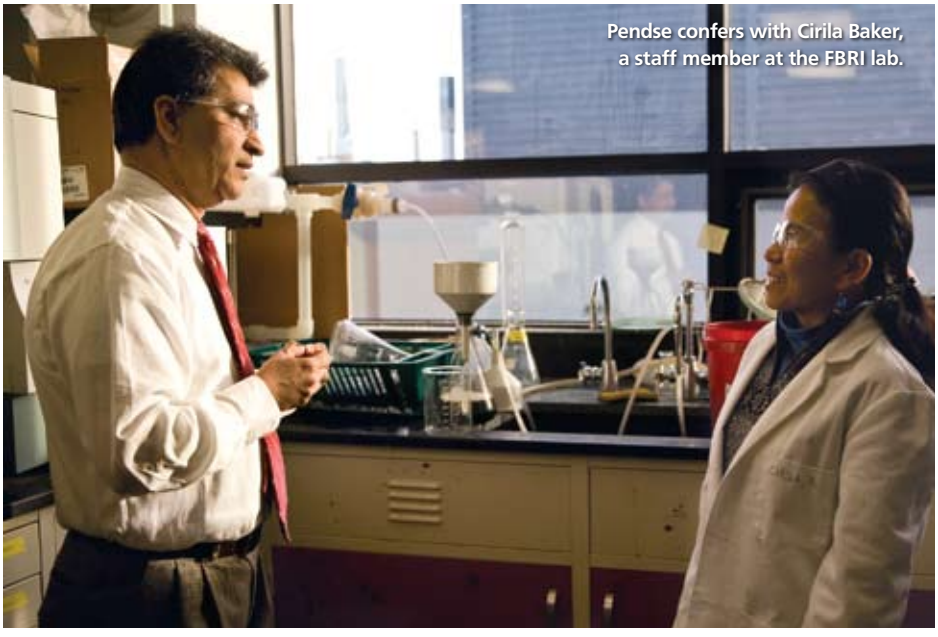
Ethanol only works with gasoline. Butanol is a more advanced fuel, and it can be used either with gasoline or diesel.

The discussion about ethanol is that right now it's being made from corn. To grow corn, you have to use fertilizer and work the farms, and it all takes energy. If you count all the energy inputs that go into growing the corn and then using the corn to make fuel, a lot of fossil fuel-based energy goes into it. That's the criticism on corn. Wood is a different case. Wood is not involved in food or feed. Even cows can't eat wood. And we use part of the wood to generate steam and power. That provides energy required for the processing step.

In our forests, we have natural growth. The energy that goes into growing trees is much less than what goes into a corn farm. For wood-based fuels, the amount of energy in the wood-derived ethanol is six to eight times more than the fossil fuel that goes into it.

Long-term, we are looking for new technologies that will allow us to make jet fuel. And jet fuel is quite interesting because, if you think about it, one day we might get electric cars that won't need much gasoline, but planes are always going to need jet fuel. And that's a huge, huge market, and right now it only comes from petroleum. There are very few test flights that are being done on what they call renewable jet fuel. Wood-derived sugars are receiving quite a bit of attention in the jet fuel technology pathway. And I know the Old Town mill owners are interested in wood-to-jet fuel.

Jet fuel has to have a property so that it will not freeze, even at minus 40°. Remember that you're flying at 30,000 feet. You cannot have your fuel freeze up there. So there are strict specifications. There are organizations, engine manufacturers, airline companies, everybody working together on the specs that the new renewable jet fuels will have to meet. The University of Maine is already an active part of a large team working on cellulosic renewable jet fuel. There are a few other places working on algae as a source, but on wood-based jet fuel, I think we are in the lead.



Pendse confers with Cirila Baker, a staff member at the FBRI lab.

What are the implications for Maine's economy?

This will give our mills an additional revenue stream while they are still making pulp. In the future, where appropriate, if someone wants to convert an old pulp mill into a fuels and chemicals facility, this will be the bridge helping them with the transition. The strengths of these mills are that they know how to handle wood, they have on-site steam and power generation, and they have the environmental permits. So they could adapt themselves. They're in a position to say, "Let's get into the fuels business; let's make jet fuel; let's make different industrial chemicals, or bioplastics."

This beaker is collecting chemicals separated from the pre-extract, which is the source of the sugars that Pendse and his team hope to turn into fuels for the future.

The new mill owners in Old Town are motivated. This project fits into their strategic plan to get into fuels and chemicals. They already have invested quite a bit of capital to make this mill suitable for fuels production. That puts them in a leadership position.

Existing mills already have steam and power plants. They have water treatment facilities; they have wood yards. They can reposition themselves. That's what the Old Town mill is trying to do. Hence the name change: Old Town Fuels and Fiber.

Our early plan is to protect the pulp production so they can make pulp of the same quality, go into the same markets, and as a by-product, or a coproduct, get the fuels. That's why our technology entered the mill—we have the potential to do that.

This means jobs and a new economy for Maine. The mills already know how to make pulp. To make all this fermentation and the new processes they need to use, they will hire new engineers. Just at the university itself, since we have been active here, we have hired several new people. And these are high-paying, research-oriented jobs.

What about beyond Maine?

Last year we collaborated between New Brunswick and Nova Scotia. We are looking on a regional basis at what opportunities exist for using the forest biomass to get different kinds of new by-products. The two provinces and the state of Maine have similar forests, and we could work together. We came up with four different technological pathways that people in companies could evaluate for themselves. We found out which universities had which research capabilities. That was the beginning of regional cooperation, and it's why folks from New York and Massachusetts are paying attention to us. We are taking this regional view as to what we can do with our own biomass.

Is all of this sustainable?

We work with UMaine's School of Forest Resources and we work with forest landowners. They can predict, through modeling, the growth in the forest. Sustainable, certified growth means that people are managing the forest with a long-term plan to make sure the growth is more than you can take out.

We want get the best and highest value out of the wood. Wood that is appropriate for the construction sector will still go into lumber. The wood that is not suitable for lumber will still go into the pulp industry. If we can extract chemicals from wood fiber that isn't being used anyway, we want to use them to make high value products.

Our forest landowners know how to do sustainable management. Our own construction companies have expertise in compact mobile modular facilities. And at the University we are working on technologies where, as appropriate, we could figure out what portion could be done in the woods and what portion needs to be done at a central processing facility.

There is already existing infrastructure for harvesting, distributing, and processing wood. We have a year-round, certified-sustainable supply. We don't have to reinvent that. We just have to be smart about how to use it. □