A CHEAPER WAY TO LICK SALT

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Source: CHRISTOPHER DINSMORE, STAFF WRITER

CHESAPEAKE - Not even Saddam Hussein could stop Leif J. **Hauge**.

After 10 years of research and development, including a stint in Kuwait cut short by the Iraqi invasion in 1990, the Norwegian inventor has perfected a device that could make desalination of sea water much more cost effective by reducing associated energy costs. And **Hauge** finished it right here. His company, Energy Recovery Inc., plans to start producing the device, known as a pressure exchanger, in Hampton Roads.

Energy Recovery will fill its first few orders out of its tiny office and machine shop in the Greenbrier Business Park. It has signed a lease to be the first tenant in Cape Charles' Sustainable Technologies Industrial Park. It should be able to move in next fall.

If all goes as planned, Energy Recovery could grow into a $60 million a year business with 50 employees in five years, **Hauge** said.

``We will expand the desalinization market very much by bringing the costs down,'' **Hauge** said with a Nordic accent. ``No doubt a lot of new water supply will come from the sea.''

Sea water accounts for 97 percent of the Earth's water. Another 2 percent is locked up in the ice caps and glaciers.

Less than 1 percent of the Earth's water is usable by humanity, and most of that is groundwater.

A recent article in the journal Science suggested that humanity will run out of usable water sources in 30 years if population growth continues, consumption rates stay where they are, and no new water sources are developed.

Well, the greatest source would be the sea. Desalination has been around for decades, but it has been problematic because of the energy required to do it.

Hauge's Energy Resources may resolve the energy issue.

``One of the principal operating costs of a sea water reverse osmosis system is energy,'' said David Furukawa, president of the International Desalination Association, based in Topsfield, Mass. ``Any kind of energy savings helps make such systems more effective.''

Furukawa observed an earlier version of **Hauge**'s device in Kuwait and said ``it certainly is unique and has the promise of being very efficient. . . ''

``The device itself has the potential of saving a lot of money,'' he said. ``The amount of money it saves is a function of how much you pay for energy.''

An efficient energy recovery system has been the holy grail of the reverse osmosis desalination industry for some time.

``Everybody is looking for something more efficient,'' Furukawa said. ``But there aren't too many modern, efficient energy recovery systems on the market.''

His pressure exchanger is much more efficient than competing systems on the market, **Hauge** said, but for now he's riding the brakes.

He doesn't want Energy Recovery to grow too fast. In fact he's not even out trying to sell the pressure exchanger and he's turning away orders. After 10 years of research and development, he doesn't want to flub the transition to production.

``He's basically been a one-man show: the inventor, the machinist, the cleaner-upper," said Dan Heflin of Norfolk-based Heflin & Williams, which has been doing business consulting for the company.

The 41-year-old **Hauge** looks the part. Bespectacled with a trim goatee, **Hauge** is at once scattered and precise, careful when choosing his words, despite a clear command of English. He dresses casually around his office, so he can work back in the shop without worrying about dirtying his clothes.

Energy Recovery employs only four people now, including **Hauge**. He's hiring four more in the first quarter. He's looking for people to help him run the business and for machine operators to help with production.

By the end of next year he expects to employ 15 people.

Energy Recovery has several contracts in hand for pressure exchangers that will be delivered in the first half of 1998 to customers mostly in the Canary Islands, where word spread fast after a prototype operated successfully there this fall.

There were 11,000 desalination plants producing 5 billion gallons of water a day in the world at the end of 1995, according the International Desalination Association. About a third of those used reverse osmosis, the market Energy Recovery will be pursuing. The number of plants is growing by up to 10 percent a year and most of the growth is in reverse osmosis.

``Energy Recovery seems to be on the verge of explosive growth," Heflin said.

``What is unknown is what this invention will do to the size of the desalting market," added Paul Williams, Heflin's partner. ``By reducing the costs associated with producing fresh water by half, it just goes out of sight."

Hauge plans to outsource the production of all parts of the pressure exchanger except for the key piece, the ceramic rotor, which he designed and learned to manufacture with an assist from the Oak Ridge National Laboratory in Tennessee.

Energy Recovery will mill, fire and grind the rotors in-house using proprietary production techniques developed by **Hauge**. The rotors must be perfectly sized. They can be no more than 1/10,000th of an inch off, or less than a micron. Energy Recovery will also assemble the pressure exchanger units.

Hauge has patented his invention in 26 countries around the world, strategically covering those markets where it could be used and where it could be produced.

``Our protection should last awhile," **Hauge** said.

The biggest question could be what to do if he gets a buyout offer. ``I'm sure we will be approached by bigger companies down the road," he said.

But **Hauge** wants to remain independent, acting as a supplier to the desalination industry while he explores other opportunities for his device.

Hauge believes the pressure exchanger could have applications in any high-pressure system. Pressure exchangers could be applied in the manufacture of some chemicals, in natural gas plants, and may even be applicable to a renewable energy idea known as osmotic power that is being examined by the Norwegian government. Osmotic power would use a mix of salt water and fresh water to spin a turbine to generate electricity in a reverse of the reverse osmosis process.

In reverse osmosis desalination, sea water is pumped at very high pressure against a membrane. About a third of the volume of water passes through the membrane as fresh water. The remaining sea water, brinier than usual, is flushed from the system.

The problem is that the brine, still under a lot of pressure, is essentially wasted energy. The energy consumed to pressurize the sea water is the principal operating cost of reverse osmosis desalination.

Hauge's pressure exchanger is placed in the brine stream and recaptures that pressure. The pressure is redirected back into the salt water stream going to the membrane reducing the energy demands on the principal pump.

The pressure exchanger is driven by the brine's pressure and requires no other external source of energy.

Starting Oct. 1, Energy Recovery field tested the latest version of the pressure exchanger at a small desalination plant at an apartment complex in the Canary Islands. The plant produces 80 cubic meters, or 20,000 gallons, of water a day.

It had consumed about 8 kilowatt hours of electricity per cubic meter of water before **Hauge**'s device was installed. The pressure exchanger cut that consumption by nearly two-thirds, to 2.8 kilowatt hours.

That energy savings means cost savings. The plant costs half as much to operate as it did before.

``That's certainly impressive,'' said the Desalination Association's Furukawa. ``That's as good or better than anything I've ever heard of.''

Furukawa wondered whether **Hauge**'s device would work as well in larger plants.

Hauge said the pressure exchanger's efficiency only gets better with more volume.

``This is a very small plant, but there's no limit of the size of plant we could do,'' **Hauge** said.

For example, Tampa, Fla., is planning to build a reverse osmosis desalination plant that would produce up to 40 million gallons of water a day. It is estimated that it will cost about $3.93 per thousand gallons of water to operate. **Hauge** estimates that if Tampa installed his pressure exchangers, it would cut operating costs to between $2 and $3 per thousand gallons.

The cost efficiencies that the pressure exchanger gives to reverse osmosis could makes desalination cost competitive with other fresh water sources. He estimates that with his technology Virginia Beach could have built a desalination plant at the same cost as the Lake Gaston pipeline.

``And you can't add capacity to a pipeline, unlike with desalinization,'' **Hauge** said.

Hauge began working on the idea of a pressure exchanger in 1987 in Norway after his younger brother challenged him to come up with a system that would bring cold water up out the depths

of a fjord to refrigerate a warehouse on his farm. At that point he hadn't even thought of applying the idea to desalination.

He began research at the Norwegian Hydrotechnical Laboratory and discovered the pressure exchanger could be applicable in desalination. With that knowledge, he began looking for research funding, which led him to the Middle East, where desalination is a principal water source.

The Kuwait Institute for Scientific Research agreed to fund three years of research and development on the project in 1989, and he moved there with his American wife Marissa and their very young daughter. By the summer of 1990, the project was well underway.

``But it came to a very quick end 2nd August 1990, when I woke up at 1 or 2 in the morning to the sound of thunder," **Hauge** said. ``But it wasn't thunder. There were some very big guns firing. The Iraqi tanks were rolling in the streets already."

Hauge, his wife and daughter tried to escape by car, but were stopped at a roadblock by the wrong end of an assault rifle. They managed to talk their way out of it and return home. It was a close call, **Hauge** said.

They attempted another escape through the desert, but turned back after hearing that Iraqi helicopters were chasing and shooting civilians.

Soon after, they decided to try their luck traveling to Baghdad, then on to Amman, Jordan. **Hauge** bribed a border guard and they got to Baghdad, but their connection to Amman didn't show up.

``We had to leave everything - our belongings, our cars," **Hauge** said. ``All we had was what we could carry."

They stayed at a Norwegian embassy official's residence. In early September, Saddam Hussein agreed to let women and children leave, and Marissa **Hauge** departed. She and her daughter came to Hampton Roads.

Hauge, meanwhile, was stuck in Baghdad until December, a month before the United States and its allies launched Desert Storm. During that time, he was free to roam around the city, as were many Westerners. He was actually quite struck by the hospitality and honesty of the Iraqi people.

He and other Norwegians built an air raid shelter under the Norwegian embassy official's house.

He also made an attempt to return to Kuwait and fetch his research, but only got permission to go about the time Saddam Hussein agreed to let the Norwegians and other Westerners leave the country. He opted to leave, flying out on the same plane as the U.S. ambassador.

After the war, he heard that there may not have been much to recover anyway. The Kuwait Institute for Scientific Research had been stripped to the walls.

He arrived in Hampton Roads with no money and only two plastic bags of clothes and ``here I am trying to fund a big research project."

He decided to stay here because his wife didn't speak Norwegian and there were top-notch suppliers and research facilities he could tap for help.

By February 1991, he had worked out a deal with a German submarine builder to test the pressure exchanger in a closed cycle diesel engine. At that point he was using metallic super

alloys for the rotor. A year later, he was also running a test with the Navy and Newport News Shipbuilding for use on submarines for desalination.

In 1994, he set up a tiny desalination plant on the Elizabeth River that showed energy savings of nearly 50 percent. But larger units were unreliable and **Hauge** began reconsidering the use of super alloys.

With the help of Heflin & Williams, he contacted Jess Brown, a professor at Virginia Tech doing ceramics research. Brown got him into the Oak Ridge National Lab in Tennessee, where he perfected the grinding techniques to smooth ceramics by 1996.

But even Oak Ridge didn't have the capability of machining the ceramics as finely as he needed.

He raised $600,000 from a group of Norwegian investors and put in the machine shop in Chesapeake. By August he had ironed out the the problems with machining ceramics.

After testing, the prototype was installed in the Canary Islands.

``Frankly speaking, I didn't expect ceramics to work,'' **Hauge** said. ``I'd have given it a 50-50 chance, but it did.''

He has since raised another $1.7 million from his investors to start up production.

His backers through the years have been very patient, **Hauge** said. ``I feel I owe them tremendously,'' he said. ``They deserve a tremendous return on their investment because they have been so patient.''

The payoff could start soon. By February he expects to have 10 more units installed in the Canary Islands. Once Energy Recovery's production facility in the Sustainable Technologies Park on the Eastern Shore is operational, the company can start really taking orders.

``It's a transition period,'' **Hauge** said. ``Right now we don't have to make any effort to get sales. They're coming to us, so we can focus on the production tune-up.''

It's been a long time coming. ``I had no idea this would take me 10 years,'' **Hauge** said. ``It's been like a desert walk.''

But now it looks like an oasis, with fresh water ahead.