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## WASTEWATER

New technology to produce pure water

## NATURAL REFRIGERANTS

Efficient reuse of CO<sub>2</sub>

## COMBINING HEAT AND POWER

An environmentally sound and lucrative solution

# ENVISIONING A GREENER FUTURE

New technology is enabling a more sustainable way of living that is bringing cities back to life.

**“You have to get rid of the energy somehow, and if you can receive some money for it, it’s even better. Plus it’s wiser from an environmental and emissions point of view.”**

*Jyrki Makkonen, production manager at Boliden, which sells its waste heat for other uses.*

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## Contributing to a better life

**editorial** Many people are waiting for new solutions to solve our energy and environmental issues, but the fact is that much of what we need is already available. Some technology will just need to be refined. I am a firm believer in the power of innovation, but I also see that unless there is strong global implementation, we will not achieve a more sustainable way of living that brings cities back to life.

Water purification is a growing issue. When can for instance raw sewage be processed into pure water? Will industries realize that it is cost-effective and environmentally sound to use it in their processes? By combining the best from two membrane technologies, a new solution is available today that improves water quality, ensures process safety and reduces operational costs.

Heat recovery is one of the most effective ways to deal with the general need for energy and reducing CO2 emissions. Boliden's sulphuric acid plant in Harjavalta, Finland demonstrates how industry can benefit from selling waste energy. During the winter, the plant supplies about two-thirds of the heat for Harjavalta's district heating network, and in the milder summer months it supplies all the heat needed for the city's domestic water.

If this can be achieved by just one company, imagine what could be accomplished on a global scale.

At Alfa Laval we have our mission in society, that provides the driving force for all employees in our daily work: We are committed to creating better everyday conditions for people. This statement is closely related to the "Better City, Better Life" theme of this year's World Expo in Shanghai which summarizes the ambition to show sustainable solutions for the future.

If you are at the World Expo I invite you to visit the Swedish pavilion show-casing Swedish innovations including some from Alfa Laval that are contributing to a better society.

I hope to see you there.

**LARS RENSTRÖM**  
PRESIDENT AND CEO, ALFA LAVAL GROUP



# CLOSING THE LOOP

**Technological innovations** have led to radical new urban sustainability initiatives. But what are the barriers to a sustainable city, and how close are we to the dream?

TEXT: PAUL REDSTONE ILLUSTRATION: ROBERT HILMERSSON

**IN THE SHADOW** of the Turning Torso skyscraper in central Malmö, Sweden, you can glimpse what urban living might be like in the future. Västra Hamnen (Western Harbour) is an attractive, modern waterfront area covering a little more than two square kilometres and housing close to 3,000 people. At first glance it looks like many other such developments, with its vibrant harbour walk, apartment buildings, shops, cafes and schools. But there's one important difference: Västra Hamnen is an area with 100 percent locally renewable energy.

The district is a beacon of innovative urban planning. The idea is that all the energy it uses should be sustainable and generated by commercially available technology. And while energy is the starting point, sustainable thinking spills over into almost every aspect of life.

The heart of the solution is a nearby wind power plant,

which provides the bulk of the electricity. Solar power is an important complement: Some 120 square metres of solar cells are integrated into the architecture, generating about 6,000 kWh of electricity per year. Solar power also provides around 10 percent of the district's heating and hot water; 2,600 square metres of solar collectors are connected to the district heating network, and any excess energy can be loaned to the rest of Malmö and returned when demand is higher.

**BUT THE BULK** (90 percent) of Västra Hamnen's heating needs is met by the sea, where boreholes up to 90 metres deep have been sunk into an aquifer. In the winter, water at 15 degrees Celsius is drawn up from the "warm side" and provides the heat source for a heat pump. After cooling, it is pumped back into the aquifer to the "cold side". During the summer, the process is reversed, to produce cooling for the district cooling network.

Little goes to waste here. Waste is treated as an energy source rather than an end product, and organic waste is converted into biogas to power homes and Malmö's city buses.

The give and take that characterizes Västra Hamnen is the key to sustainability in cities. Sustainable development

is often likened to a three-legged stool, the essential supporting elements being the environment, economic development and social equity.

Ultimately it all comes down to energy, says Michael Herrmann, a sustainability expert at Kingston University in the UK. "Sustainability is a loop," he says, "and energy and material flows need to be seen as cyclical rather than linear. The ideal is what's known as a closed-loop system via reuse and recycling – zero waste, as in nature, where the by-products of one system become the food for another."

An excellent example of this principle, Herrmann says, is the Kalundborg industry zone close to Copenhagen in Denmark. "Kalundborg is an industrial symbiosis, where one company's waste product becomes an important resource for others," he says. "Fewer resources are consumed, and environmental impact is significantly reduced."

**THE ZONE IS A COOPERATION** between the municipality of Kalundborg and seven commercial operations. The companies boost their bottom line by making use of each other's waste or by-products on a commercial basis. They also gain a great deal of goodwill from the ecological

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**“As more and more companies begin to see the economic benefits and new revenue possibilities, the driving force for change will go beyond environmental benefits.”**

ROBERT VOS, *University of Southern California*



>>> benefits to the region. It's a true win-win situation whereby waste from the Asnæs Power Station, in the form of steam and hot water, is used to heat tanks in a fish farm, as well as providing heating for the Kalundborg municipality and the Novo Nordisk pharmaceutical plant. For its part, Novo Nordisk produces organic sludge waste that becomes fertilizer for farms. And so on.

When it comes to urban sustainability, Herrmann says, buildings will always be an important focus – particularly when you consider that around half of the world's greenhouse gas emissions relate to building, from the energy embodied in the materials to construction, running and maintaining the building and eventually decommissioning it. That makes architecture a very significant factor as we seek greater environmental sustainability.”

**INNOVATIVE HANDLING** of waste is also a factor for architecture. A surprising sustainability initiative is London's 2012 Olympics development, heralded as the Green Games. For example, Olympic Park, Europe's largest new urban park in 150 years, will reuse at least 90 percent of the materials from the demolition site, including paving stones, bricks from old buildings and timber. Using on-site materials means a significant reduction in transport requirements, among other things. A related initiative, the Capital Growth project, is turning derelict land and other under-used or redundant space into vegetable gardens to grow local produce. As well as creating more attractive local environments, the 100 or so spaces already under development around the city will also improve air quality as they trap pollutants and absorb CO<sub>2</sub>.

When it comes to conserving resources, one of the most important to conserve is water. Singapore, for example, an industrial nation with limited water sources, currently imports most of its fresh water from neighbouring Malaysia. Concern over water security has led the country to look seriously at the reuse of wastewater. A large-scale wastewater purification plant is currently being built in the Changi region. When fully operational, it will have the capacity to produce 228,000 cubic metres of water per day, both for drinking and for industrial use. The plant is based

on reverse osmosis membrane technology, a promising approach now being deployed worldwide. Water treatment plants using membrane technology require less space than conventional plants, an important factor in urban areas, and are relatively affordable.

**ROBERT VOS, ASSISTANT PROFESSOR** (research) of geography at the University of Southern California and formerly with the Center for Sustainable Cities, points out that closing the loop goes right to the heart of society.

“The right mindset is critical for any city,” Vos says. “The Bruntland Report made it clear that sustainability is also about the economy and social equity, and how these are tied together. Cities must consider this. Environmental quality must be linked to the social fabric of the community and contribute to the vibrant economy that people want. And as more and more companies begin to see the economic benefits and new revenue possibilities, the driving force for change will go beyond environmental benefits. Every city has unique concerns, and it's important to develop relevant sustainability indicators in agreement with local communities.”

In other words, it is integrated thinking that will make experiments such as Malmö's Västra Hamnen possible on a much larger scale.

For the future of sustainability, Vos adds, one of the most important issues to tackle is actually employment. “Cities have to reconcile environmental goals with providing good jobs and enough jobs,” he says. “In the US, the creation of so-called ‘green collar’ jobs has been one of the biggest political topics since the recession. That means jobs that benefit the environment and help reduce waste and pollution but can also provide a long-term career path. Sustainability has far-reaching implications. You have to think – and act – beyond the obvious.” ■



# PARISIAN PLUMBING

**A city of 8.5 million** needs a wastewater system that is reliable and efficient and up to the challenges of population and weather. In Paris, the Achères treatment facility has chosen Alfa Laval.

TEXT: ANNA McQUEEN PHOTOS: ALASTAIR MILLER & GETTY IMAGES

**WHEN TAKING THAT DREAM** vacation to Paris, the City of Light, not many tourists spare a thought for what happens to what they leave behind. But as they stroll along the boulevards or along the banks of the Seine, they might be impressed to know that to the west of the city, the Achères wastewater treatment plant is working round-the-clock to process up to 2 million cubic metres of wastewater generated every day by the city's inhabitants and visitors and by inclement weather.

The Achères facility is the biggest wastewater treatment plant of its kind in Europe, second only to Chicago's on a global scale. A treatment facility has existed on the site since the end of the 19th century, but the current facility was constructed in 1940, and in 1970, it became part of the network managed by

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The Archères wastewater treatment plant is the largest of its kind in Europe. Each day, it processes up to 2 million cubic metres of wastewater.



>>> the Syndicat Interdépartemental Pour l'Assainissement de l'Agglomération Parisienne (SIAAP).

Key to the smooth running of this essential public service are industrial partners who can meet the challenge of such a high-turnover operation. And that is why, when the old Alfa Laval heat exchangers in the sludge conditioning digesters in the Achères III facility began to show signs of wear and tear, the SIAAP decided to return to Alfa Laval for replacement parts.



Digestion Manager André Pensard monitors a crucial stage of the waste treatment process.

**“WE’D HAD THESE SIX SPIRAL HEAT** exchangers in service since 1972, and they had served their time very well,” explains Daniel Alibert, manager of the Biogaz Digestion Production Unit at the Achères plant. “Then in 2003, after more than 30 years of service, we noticed one of them needed to be replaced. We were so happy with the longevity of the product that we decided to contact Alfa Laval and replace it with the exact same model. When another exchanger needed replacing a year later, we decided to replace them all.”

The Achères site has undergone a full reorganization and retrofit, including a complete management reshuffle that set the project timeline back a bit, but the last spiral exchanger was finally fitted in December 2009. “With such a big project, we had to put out a call for tenders, but in the

**“This is an aggressive environment where problems of corrosion are commonplace, so the materials we use must stand up to that.”**

**DANIEL ALIBERT**, manager of the Biogaz Digestion Production Unit

end we chose Alfa Laval,” says Alibert. “It didn’t come down to a question of cost; our choice was based on the 30 years of experience we’d had with Alfa Laval spiral exchangers in the digesters and the 30 more years we’re hoping to get.”

After an initial pretreatment to remove the largest waste, wastewater for treatment is decanted and then the sludge is aerated, which is when the natural bacterial processing takes place. It then undergoes a digestion process where it is heated to 35 degrees Celsius. The methane that comes off the waste is recycled as a source of energy for the plant to heat the exchangers in the digesters, to run the machines to aerate the aeration basins and for everyday energy on



Daniel Alibert, manager, Achères plant (left), and Olivier Toniello, Alfa Laval engineer, are satisfied with the recent retrofit.



Robust spiral exchangers from Alfa Laval.

site. Some 60 percent of the site's electricity needs are generated in this way.

The resulting sludge then undergoes a final treatment during which it is sterilized with the addition of steam at 180 degrees Celsius before being pressed and then handed over to the agricultural industry for use as fertilizer.

"All the materials we use must be of the highest standard," says André Pensard, digestion manager. "Digestion is a crucial stage of the waste treatment process. If we can't maintain the right temperature, not enough gas is created, and that could lead to all sorts of problems. But the Alfa Laval exchangers never break down."

Of all the exchangers used for digestion by the Achères site, 50 percent are currently Alfa Laval spiral exchangers and the rest are traditional tubular exchangers. "The spiral exchangers are very reliable and simple to maintain," says Pensard. "Moreover, we'd never fit tubular ones in the space we have available here. They're six times the size."

Indeed, the SIAAP is so pleased with the performance of the Alfa Laval spiral exchangers that it has ordered eight more to replace the spiral exchangers in the Achères III facility and five to replace tubular exchangers in the Achères II facility. "This is an aggressive environment where problems of corrosion are commonplace, so the

materials we use must stand up to that," says Alibert. "We need robust and lasting quality, and Alfa Laval spiral exchangers have demonstrated that they are more than capable of meeting our needs and those of 8.5 million Parisians every day!" ■

► Facts

THIS IS SIAAP

- The SIAAP (Syndicat Interdépartemental Pour l'Assainissement de l'Agglomération Parisienne) was created in 1970 and handles wastewater treatment for the four départements of the Ile-de France region – Paris, Val-de-Marne, Seine-Saint-Denis and Hauts-de-Seine – as well as 180 municipalities in the surrounding Val d'Oise, Essonne, Seine-et-Marne and Yvelines. It is administered by 33 councillors, who are selected by the four founding departments, and financed by water utility charges and various grants.
- The SIAAP employs a team of 1,700 to manage five treatment plants covering almost 2,000 square kilometres of pipe, reaching some 420 kilometres around the region, and storage facilities of more than 900,000 cubic metres, managing more than 2,500,000 cubic metres of wastewater every day.

# Bringing wastewater back to life

**Can raw sewage** really be processed into pure water? Will industries realize that it is cost-effective and environmentally sound to use it in their processes? The water reuse industry is growing, and technology is growing along with it. Now it's taken another step forward with Alfa Laval's latest advance in membrane technology.

TEXT: JOANIE RAFIDI ILLUSTRATION: TOMAS ÖHRLING

**ALFA LAVAL HAS BEEN** in the wastewater treatment business for more than 50 years. Products such as decanter centrifuges, drum thickeners and spiral heat exchangers are being used in wastewater and sludge treatment for municipal and industrial applications involving more than 250 million users. Recently another technology has been added to the portfolio.

This latest technology, the Hollow Sheet from Alfa Laval, has been developed under the leadership of Nicolas Heinen, who has extensive experience in membrane filtration and wastewater treatment. Alfa Laval is now entering the MBR market with the Hollow Sheet Membrane Filtration Module, challenging existing products on the market. MBR is a growing technology for wastewater treatment driven by improved treatment processes, stronger effluent requirements and water reuse.

#### What makes the Alfa Laval solution unique?

"We have combined the best from two membrane technologies – hollow fibre technology and flat sheet technology, which are both currently used in MBRs installed in wastewater treatment facilities – and turned them into one membrane configuration," says Ivar Madsen, manager, MBR Unit, Alfa Laval.

Hollow fibre and flat sheet membranes each offer advantages, but until the advent of the Hollow Sheet technology, no membrane has been able to combine the advantages of both products into one. "With the Alfa Laval Hollow Sheet in the MBR, you get complete utilization of the whole membrane area," explains Madsen. "This results in a much greater filtration capacity and at the same time



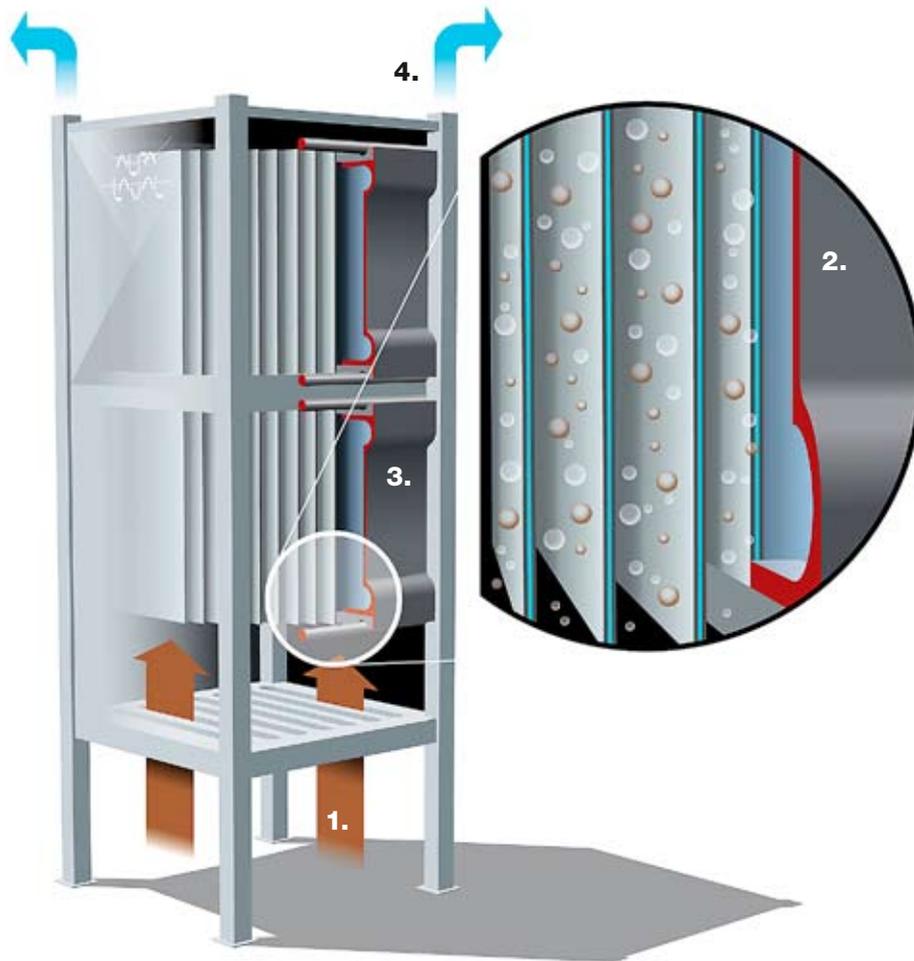
Ivar Madsen, Alfa Laval.

lower energy consumption – 10 to 25 percent lower air consumption per membrane area than what is achieved by the flat sheet and hollow fibre membranes currently in use. Using the Hollow Sheet instead of the other technologies therefore translates into substantial energy savings."

A Hollow Sheet MBR is designed with a cross-flow velocity of water and waste materials flowing upwards between the membrane elements while the water (permeate) passes through the membrane sheet. To ensure that this mixed liquid circulates effectively, air bubbles are used to create this cross-flow velocity while providing a scouring effect. The Hollow Sheet membranes are placed in a stainless steel frame within the Alfa Laval Membrane Filtration Module.

**THE HOLLOW SHEET** features taller and wider membranes than anything else currently available, producing an optimized packing density. This design (see illustration) ensures that cleaned effluent is drained from the entire surface of the membrane, exiting through connectors at the top of the unit. This means that the pressure drop over the membrane is close to zero due to an open permeate system. Since the Hollow Sheet has a low transmembrane pressure (TMP) while flowing through the membrane, an MBR plant will be simpler and easier to operate because it doesn't require complicated vacuum systems that are

► How it works



**The Hollow Sheet** features taller and wider membranes than anything else currently available, producing an optimized packing density. This design ensures that cleaned effluent is drained from the entire surface of the membrane, exiting through connectors at the top of the unit.

1. The complete Membrane Filtration Module is submerged in the MBR tank. Wastewater sludge enters the module from below and is lifted upwards in a cross-flow generated by a built-in aerator.
2. Water is filtered from the sludge through the membrane pores and drained through the Hollow Sheet.
3. The cleaned water (permeate) passes through hundreds of built-in channels and is collected in the module's Hollow Sheet pipes.
4. The filtered water exits through the top of the Membrane Filtration Module and is piped to the tank outlet for reuse or further processing.

present in MBRs today. This extremely low TMP (a factor of 10 lower) means that membranes are operated by gravity. This low-pressure operation reduces fouling on the membranes, thus reducing the need for cleaning.

As urban populations grow, municipal and industrial wastewater treatment will become a priority, Madsen says, noting that within the next 20 years, water reuse will become an everyday technology mainly because municipalities and industries will be forced to use it.

**MADSEN FORESEES OPPORTUNITIES** in municipal wastewater for protection of sensitive rivers, as well as for water reinjection underground or irrigation. The Alfa Laval system was recently approved by the Californian authorities for water recycling purposes (California Title 22 Approval). Water reuse can also be an opportunity for industries, depending on processes and water criteria.

The opportunity for companies and organizations to improve wastewater treatment processes and make the reuse of water possible has a positive effect on the environ-

**“We have combined the best from two membrane technologies – hollow fibre technology and flat sheet technology.”**

*IVAR MADSEN, manager, MBR Unit, Alfa Laval*

ment and in protecting water resources. “The higher the price for raw water and wastewater treatment, the better the return on investment will be for the MBR,” says Madsen.

Alfa Laval is looking for ways to improve even further, and it is currently participating in the Danish research programme Membio, where leading universities and institutes in wastewater technology are focusing on system cost, performance, packing density and energy consumption. ■

# HEATING UP HARJAVALTA

**Boliden Harjavalta Oy** in Finland is generating warmth and good will in the community of Harjavalta by recovering heat from its production of sulphuric acid and channelling it into the district-heating network. The heat recovery has also lowered energy costs for Boliden's own copper- and nickel-processing facilities nearby.

TEXT: JACK JACKSON PHOTOS: LIISA VALONEN



## HEAT RECOVERY

In Harjavalta, a town in Western Finland, residents can thank a local sulphuric acid plant for helping to keep them warm.

The plant, owned by Swedish metals company Boliden, recovers so much heat from its production of sulphuric acid that it channels part of the heat to the Harjavalta district heating network and uses the rest in its other factories on site, including copper- and nickel-processing facilities.

If this 20 MW of total recovered heat had been generated from oil (priced at USD 70 per barrel), it would have cost around USD 9.5 million per year and generated about 40,000 tonnes of CO<sub>2</sub> emissions – assuming typical values of boiler efficiency and heat of combustion and 350 days of operation per year. To simplify this estimate, every 1 MW of recovered heat saves about 2,000 tonnes of CO<sub>2</sub> emissions and a half million dollars in fuel costs annually at today's rates.

"It's one way we can benefit – by selling the energy," says Jyrki Makkonen, production manager, Boliden Harjavalta Oy. "And then of course the community benefits too. They can avoid burning fuel or investing in new equipment for their district heating plant. Instead, they can buy the energy from us."

Harjavalta is a historic landmark in the mineral-processing industry. It's a town of about 8,000 people on the southwest coast of Finland, about 50 kilometres from the sea. It was here that the process of flash smelting was developed for metal recovery in 1949, first for copper ore and then for nickel and lead.

"The beauty of flash smelting is that you use the energy contained in the metal concentrate itself for separating the mineral from the ore," says Makkonen. The dried and powdered ore ignites when mixed with oxygen, leaving the metal to melt and drop to the floor of a settling chamber. "You are burning the sulphur and the iron from the concentrate instead of using external energy," he says.

The popularity of this technique caught on, and today it is one of the most widely used smelting methods of copper concentrates in the world, Makkonen says.

**BECAUSE FLASH SMELTING** generates polluting sulphuric dioxide (SO<sub>2</sub>) emissions, mineral processing plants



Copper and nickel smelting and sulphuric acid production are all part of Boliden Harjavalta's daily operations.

### ► Facts



### THIS IS BOLIDEN

- Boliden Harjavalta Oy smelts copper concentrates, refines copper, smelts nickel concentrates and produces sulphuric acid, the most widely used chemical in the world.
- The company has about 400 employees and is part of the Business Area Smelters of the Boliden Group, one of the leading metals companies in Europe, with operations in Sweden, Finland, Norway and Ireland.
- Boliden's core competence is in the fields of exploration, mining, smelting and recycling. Parent company Boliden employs about 4,600 people and has an annual turnover of about EUR 3 billion a year.
- Boliden's shares are listed on Stockholmsbörsen's Large Cap list and on the Toronto Stock Exchange in Canada.

commonly build a sulphuric acid plant nearby to turn that dangerous gas into something useful. Sulphuric acid is in fact "one of the most important of all chemicals," according to Encyclopædia Britannica.

It is here that the advances in heat recovery over the past few decades have changed the sulphur-burning acid factories from local and environmental irritations – emitting hot water directly into oceans or rivers – to money- and climate-saving heroes.

"When you make sulphuric acid, you produce a lot of heat," Makkonen says. "You have to remove that heat somehow." Part of this is used to make high-pressure steam, which can be used to generate electrical energy or other purposes on-site. The rest is removed in the form of hot water.

Until 1995, Boliden Harjavalta emitted this hot water directly into the nearby Kokemäenjoki River, heating it up and altering the marine environment. But then it reconstructed its plant's cooling system to include plateheat



► Facts

## SULPHURIC ACID

- With 195 million tonnes of sulphuric acid produced in 2008 alone, the potential to recover heat and at the same time lower CO<sub>2</sub> emissions is enormous. Based on the calculated savings at Harjavalta, global application of such plate heat exchangers on sulphuric acid plants could save more than 5 million tonnes of CO<sub>2</sub> a year and more than USD 700 million from the higher energy efficiency, according to Alfa Laval's Magnus Edmén, business development manager, market unit Inorganics, Metals and Paper.
- Sulphuric acid is widely used in the chemical industry for the manufacture of fertilizers, batteries, pharmaceuticals, paper, plastic materials and detergents among other products.
- The US is the biggest sulphur-producing nation, followed by Canada. Together, they produce about 30 percent of the total world output. The main consumers of sulphuric acid are large fertilizer producers in the US, Morocco, Tunisia, India, China and Brazil.

Sources: Merchant Research & Consulting, Ltd and the European Sulphuric Acid Association

exchangers in a closed-loop cooling circuit, says Makkonen.

The demineralised water circuit heats the district heating water from 60 to 90 degrees Celsius in the Alfa Laval plate heat exchangers. The temperature in the district heating circuit can be raised to up to 115 degrees Celsius by other equipment at the sulphuric acid plant.

**BOLIDEN HARJAVALTA** is the Nordic region's largest sulphuric acid plant, producing about 600,000 tonnes of sulphuric acid a year. The closed-loop circuit recovers 10 MW for heating Boliden's nickel and copper production plants in the area and recovers another 10 MW for the municipal district-heating network.

"It's a nice side product," Makkonen says. "You have to get rid of the energy somehow, and if you can receive some money for it, it's even better. Plus it's wiser from an environmental and emissions point of view."

In the winter, Boliden Harjavalta supplies about two-thirds of the heat for Harjavalta's district heating network,

**"The community benefits too. They can avoid burning fuel or investing in new equipment for their district heating plant. Instead, they can buy the energy from us."**

JYRKI MAKKONEN, production manager, Boliden Harjavalta Oy

and in the milder summer months it supplies all the heat needed for the city's domestic water.

"It's straightforward," Makkonen says. "You turn the energy you have into hot water. Using this hot water is just pure engineering. The tricky part is to figure out the customer and what needs to be heated. Flats, houses, greenhouses, swimming pools, whatever. Just get your thinking 'out of the box' and widen your scope. Whatever needs to be heated, just heat it." ■

Find out how Boliden uses plate heat exchangers to recover heat – next page >>>



# From acid to eels

**A chemical plant** in southern Sweden is cutting down on waste by using recovered heat and water to produce a slippery delicacy.

TEXT: JACK JACKSON PHOTO: GETTY IMAGES

**THE KEMIRA CHEMICAL** plant in Helsingborg, Sweden, uses some of the 22 MW of heat it recovers from sulphuric acid production to start up a side business not usually connected to chemical factories: an eel farm.

The Kemira chemical company founded Scandinavian Silver Eel (SSE) in the mid-1980s to exploit the brackish cooling water in the sulphuric acid plants. It began as just a “wild idea”, says Sara Jönsson, plant manager, Pulp Chemicals Production, Kemira Kemi AB.

“It started as a project on what Kemira could do with the warm salt water that was just pumped back into the sea,” Jönsson says. “At the time, heat recovery was not as prevalent, and some heat was just cooled with salt water and pumped back to the ocean. Someone who had knowledge about eels came up with the idea to farm eels with this warm salt water.”

**KEMIRA REDESIGNED** its plant in the mid-1980s, installing Alfa Laval plate heat exchangers in a closed-loop cooling circuit. With this heat recovery system, the heat from the acid production transfers to a closed-loop circuit. Most of the heat in this circuit warms up district heating water through plate heat exchangers for the city of Helsingborg. The remainder is used on site in an internal heating loop, and

this also warms the closed recirculating system of the eel farm, Jönsson says.

An important part of SSE’s business is to help maintain the eel population around the Baltic Sea. “Scandinavian Silver Eel has been involved in the restocking of small eels since 1984, and with others we have achieved significant numbers of mature [silver] restocked eels leaving the Baltic,” says the company’s Richard Fordham.

**BABY “GLASS” EELS** are imported from England’s River Severn, where the stable eel population and environmental factors make it tough for a large proportion of the baby eels to survive. Since they are too weak to search for a new habitat and would otherwise die, some of the excess glass eels are sent to restocking programmes such as that at SSE, Fordham says.

The eels spend nine weeks in quarantine after they arrive to check that they are not carrying a disease. Two-thirds of them are then sent onwards to restocking programmes in rivers and lakes in Sweden, as well as in Finland, Germany, Poland and Hungary. The remainder grow on the farm for about 18 months until they are ready to be sold for consumption – a Scandinavian delicacy.

Since 1984 SSE has released more than 23 million small eels into the wild in Sweden. ■

## ► Alfa Laval’s solution

### Strong enough for sulphur

**The Boliden Harjavalta and Kemira** sulphuric acid plants (see main stories) both recover waste heat with semi-welded Alfa Laval plate heat exchangers.

“It was the introduction of D205 material in the plate heat exchangers that made this possible,” says Magnus Renlund, segment manager, Process Industry and Power, Alfa Laval Nordic. Two of the most important components of D205 material are nickel alloy and its silica content.

“When you’re dealing with sulphuric acid, you need certain plate materials that can withstand strong, concentrated, sulphuric acid.”

In such plants, plate heat exchangers make it possible to economically recover the heat from the circulating acid in the drying and absorption towers. By installing a closed loop of cooling water, the heat can be used for a range of purposes, such as district heating, boiler feed water preheating, process heating in adjacent plants, space heating of factories and offices, production of freshwater by desalination, and the enabling of more internal electricity generation from waste steam, Renlund says.

How much a plant saves on its own energy costs through this process

depends upon many factors, including technology supplier, other investments in energy efficiency and climate around the plant, he adds.

The payback time for plate heat exchanger installation depends on the specific application, Renlund says. “Payback time is usually from half a year to three years,” he says. “But on average, if we estimate from what we hear from our customers, it might be less than one year for the investment. And anyway, recovering energy goes in line with reducing CO<sub>2</sub> emissions. This is energy that can and should be used.”

It takes more than 50 gasketed plate heat exchangers to cool the 160-storey Burj Khalifa tower.



PHOTO: EMAAR PROPERTIES

## Record-breaking tower

**In January 2010**, the world's tallest man-made structure was inaugurated in United Arab Emirates. Built by real estate giant Emaar, the Burj Khalifa tower soars more than 800 metres above ground.

The tower is the centrepiece of downtown Dubai, a 20 billion US dollar mixed-use development that includes residential apartments, office space, several retail outlets and the world's largest shopping mall, the Dubai Mall. The 160-storey tower also houses the world's first Armani Hotel.

Alfa Laval technology forms a major part of the cooling infrastructure. In the tower alone, there are 52 gasketed plate heat exchangers for HVAC, domestic water cooling and swimming pool applications. The Burj district itself is densely equipped with Alfa Laval technology. Alfa Laval heat exchangers are found in a majority of the buildings in the district, interfacing between the buildings, the district cooling chilled water supply and thermal energy storage infrastructure.

On its route to the top of the world, Burj Khalifa has overtaken tall buildings across the globe, including, in the US, the KVLV-TV mast in North Dakota (628.8 metres) and the Sears Tower (442 metres), as well as the Petronas Towers in Malaysia (452 metres) and Jin Mao building in Shanghai, China (421 metres). ■

## Staying with a winner

**Termocom**, a district heating company in Moldova, is sticking with Alfa Laval for the second stage of a large housing project in the capital city of Chisinau.

Alfa Laval delivered 33 heat exchanger

systems (HES) units to Termocom in July 2009. Just four months later, Termocom placed another order for an additional 67 HES units.

The two companies have been working together since 1998, and despite tough competition from other market players for the latest order, Termocom chose to remain

with Alfa Laval. "We are reliable and have had the chance to prove it to the customer in previous contacts," says Magnus Edin, business unit manager, Comfort/HVAC.

The 100 tried and tested HES units are warming up the residents of Chisinau with a cost-efficient heating solution

that consumes much less energy than in the past.

"We are replacing old equipment with new equipment that is efficient and uses modern technology. In the old [district heating] systems, people could be forced to open a window to balance the excess heat."

Not any more. ■



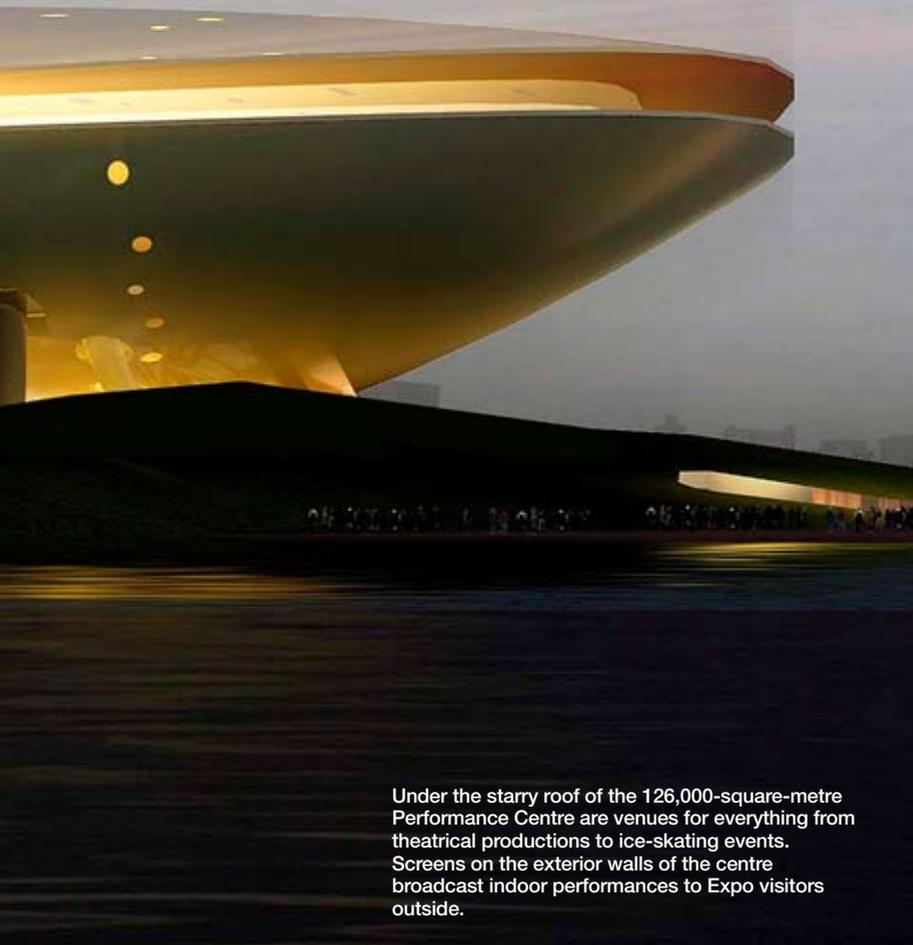
# WORLD EXPO HAS LANDED



**The resplendent new Shanghai Expo Performance Centre** integrates people, city and culture, giving visitors an experience of urban life at its future best. The 126,000-square-metre building features many environmentally friendly solutions, including one used in the centre's ice-skating rinks.

TEXT: RITA YAO PHOTOS: GETTY IMAGES ILLUSTRATIONS: WORLD EXPO 2010

# 2010



Under the starry roof of the 126,000-square-metre Performance Centre are venues for everything from theatrical productions to ice-skating events. Screens on the exterior walls of the centre broadcast indoor performances to Expo visitors outside.

**A GEM AMONG THE CUTTING-EDGE CONSTRUCTION** for the World Expo 2010 Shanghai, China, is the spectacular new Expo Performance Centre. The building, which looks like a flying saucer, has been in the spotlight since construction began in December 2007. To match Expo 2010's theme, "Better City, Better Life", the centre is expected to become a multi-functional facility for cultural and entertainment activities and a new landmark for the city.

The performance centre is one of five permanent



The spotlight is on urban environments when Shanghai, China hosts the World Expo from May to October.

buildings built for the six-month Expo, which begins on 1 May 2010. The four others are the China Pavilion, the Theme Pavilion, the Expo Centre and Expo Boulevard. The performance centre will host many of the 20,000 performances during the Expo.

Situated on the eastern bank of the Huangpu River, the new centre has 126,000 square metres of floor space, with two storeys below ground and four above. The underground space includes a commercial area, a parking lot, a public ice-skating rink and supporting facilities. The main auditorium is above ground. With a central stage, the auditorium will become China's largest performance arena. It can accommodate 4,000, 8,000, 12,000 or 18,000 people, depending on the requirements of the performance and the anticipated audience size. There will also be venues for different forms of entertainment, such as a theatre, bars, clubs and restaurants.

The roof of the centre is dotted with lights to create the effect of a starry night, and the exterior walls of the centre are equipped with huge screens to broadcast outside the performances being held inside.

**AS AN ECHO TO THE EXPO 2010'S THEME**, the performance centre also embodies the harmony between humans and nature, showcasing its environmental protection mindset. It will feature a rain-collection system that will gather water suitable for activities such as cleaning and watering plants. Water from the Huangpu River will be used in the air-conditioning system within the centre.

Expo Performance Centre designer Wang Xiao'an, a chief architect with the Shanghai Xian Dai Architectural Design Group, explained his concept to the Oriental Morning Post: "The centre is designed to merge culture with high-tech, the present with the future, and China with the world."

For the long-term operation of the centre after Expo 2010 ends, the central stage can be transformed into an ice arena for ice hockey matches and ice-skating performances or into a standard NBA basketball court. Some 250 perfor-

>>>



>>> mances and/or sport events are expected to be held in the centre each year following the Expo.

The two ice-skating venues – the public and the performance rinks – are especially attractive as Shanghai, a southern city, has no ice hockey arena.

**CTC INDUSTRIES (BEIJING) LTD** WON the job of building the two rinks. The company is a partner and the exclusive distributor of CIMCO Refrigeration, a company based in North America that specializes in the engineering, design,

manufacture, installation and service of industrial, process cooling and recreational refrigeration systems.

With almost a century of experience, CIMCO Refrigeration has built more than 5,000 ice-skating rinks around the world. It partnered with CTC in a bid to introduce its leading energy-saving technology to China.

“We pay a lot of attention to the environment and continue to seek to reduce energy consumption in all our projects,” says Clifford Dang, engineering manager at CTC Industries (Beijing) Ltd.

► The Alfa Laval solution

## Feeling the chill

**Expo 2010** Shanghai’s Performance Centre has been designed as an environmentally friendly building and will use water from the Huangpu River to form a special air-conditioning system within the centre.

CTC’s Eco Chill system is also connected to the air-conditioning system. A gasket plate heat exchanger from Alfa Laval is used to capture the recovered heat and the excess heat from the refrigeration process and transfer it to the air-conditioning system.

“Three AlfaNova plate heat exchangers in the refrigeration system are used as condensers to cool the refrigerant

from compressors, and the semi-welded units act as evaporators to cool down the freezing protected water (brine), which will be sent back to compressors to start a new round of refrigeration,” says Yuan Ling, sales manager of Comfort and Refrigeration Equipment from Alfa Laval. “In the application of the two rinks, refrigerant and the material facilitating cooling are in a totally enclosed circuit,” he says.

The AlfaNova is a 100 percent stainless steel plate heat exchanger and is a unique product from Alfa Laval. Compared with traditional brazed plate heat exchangers, it has excellent sealing performance



and can better prevent the leaking of refrigerant. Moreover, it can withstand extremely low temperatures and is much more compact and corrosion-resistant.

**“We pay a lot of attention to the environment and continue to seek to reduce energy consumption in all our projects.”**

**CLIFFORD DANG**, *engineering manager at CTC Industries (Beijing) Ltd*

“We introduced CIMCO’s Eco Chill system to reclaim the heat produced in the refrigeration process that has been used in the two skating rinks in the centre,” he says. “This is the first time that we are using this kind of system in China.” The recovered heat is used to provide heating for the building.

An Alfa Laval plate exchanger used in the Eco Chill system plays a vital role in capturing and transferring the heat from the refrigeration system to the cooling and heating system within the centre. According to Dang, the system has won great acclaim in North America by helping to reuse and retrieve heat, making considerable contributions to conserving energy. In the past, such heat was released from the refrigeration system into the surroundings and wasted.

**CONSTRUCTION ON THE TWO RINKS** started in July 2009 and was completed in December 2009. “The project was not at all difficult for us, as we have plenty of experience building similar rinks around the world,” says Dang.

Due to the long-term – about 15 years – cooperation between CIMCO and Alfa Laval in North America, CTC has also chosen to partner with Alfa Laval since the company was formed in 2003. “What is most important is that Alfa Laval’s plate heat exchangers are reliable and almost maintenance-free,” says Dang.

A total of seven Alfa Laval plate heat exchangers are used in the Expo Performance Centre.

“The plate heat exchangers fully comply with our requirements for low-energy consumption,” Dang says. “Indeed, when energy recovery is considered, our whole system consumes up to 50 percent less energy than that of some other competitors in China. For a typical ice rink, this can mean an annual saving of 73,000 [US] dollars. The Expo organizers think highly of this aspect.” ■



► Inside the Expo pavilions



## Alfa Laval and World Expo 2010

Some 200 countries and international organizations are participating in the World Expo 2010 Shanghai, China. The grand gala, which will run from 1 May to 31 October, is expected to draw nearly 100 million visitors from all over the world.

**The theme of Expo 2010** is “Better City, Better Life”, representing the common wish of mankind for a better lifestyle in future urban environments. This theme represents a central concern for the international community in terms of future policy-making, urban strategies and sustainable development.

The Expo site covers a total of 5.28 square kilometres, including an enclosed area and outside areas for support facilities. It spans both sides of the Huangpu River and is in both the Pudong and Puxi districts of Shanghai. There are 12 pavilion groups, eight in the Pudong section and four in Puxi, each covering about 10 to 15 hectares.

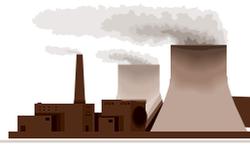
Alfa Laval is involved in this event. In addition to providing seven plate heat exchangers to the Expo Performance Centre, it has supplied plate heat exchangers to other pavilions: two in the SAIC-GM

Pavilion, one in the China Mobile-Denmark Telecom Pavilion and two in the Sweden Expo 2010 Official Partner.

In the Swedish pavilion the exhibition is built around the “Spirit of innovation” showing how Swedish companies and innovations contribute to a better society. Alfa Laval will be presenting two products here: the “MiniCity” for district heating and cooling and PureBallast, the chemical-free ballast treatment system, developed in cooperation with Wallenius Water.

From 25–29 May, Alfa Laval will also host special customer days including some 20 seminars covering cutting-edge technology solutions within energy, the environment, food and pharmaceuticals.

►► <http://www.alfalaval.com/worldexpo2010>



# Micro power to the people

**Combined heat and power technology** has traditionally been reserved for medium to large-scale installations serving communities and industry. Today a revolution in thinking has led to the development of this technology for residential homes.

TEXT: **ELAINE McCCLARENCE** ILLUSTRATION: **KJELL ERIKSSON**

**THE POTENTIAL FOR** homeowners to lower their energy bills and reduce carbon emissions by using less energy is driving micro combined heat and power developments in the residential sector.

Major gas boiler companies in Europe are investing heavily in micro combined heat and power (micro CHP), a technology that uses natural gas to generate heating and part of the electricity requirements for households. Over the past three years an increasing number of products have been launched to support the micro-CHP concept.

In a micro-CHP system, a micro-CHP unit replaces a gas central heating boiler. It provides heat and hot water as

usual, but additionally provides the majority of a home's electricity needs (see sidebar on next page).

With the European gas boiler market estimated at 5 million units annually and with more than 100 million gas boilers already installed, there is considerable potential for this new technology.

**GENERAL INDUSTRY FIGURES** put the extra cost of buying and installing micro-CHP units at between 1,000 and 2,000 euros and payback at between five and 15 years.

Energetix, which is developing micro-CHP technology for use in European markets and is collaborating with Alfa Laval, believes that its micro-CHP technology, based on a robust heat and power generation system, could provide annual savings of at least EUR 165 with a payback time of just three to five years. The consumer also reaps the benefits of increased efficiency of energy conversion and use.

Several countries where gas boiler installation is high, such as the Netherlands, the UK, Germany, Belgium and Luxembourg, are offering household subsidies, and this is fuelling interest in micro-CHP technology, according to Geoff Barker, head of marketing and sales at Energetix.

In the Netherlands, homeowners are offered a EUR 4,000 grant towards the cost of a new micro-CHP system. Germany is offering payments based on how much electricity the homeowner generates. The first users will be offered generous rates or tariffs. A similar tariff-type scheme is planned for the UK. In addition, the UK government is going one step further by launching the "Great British Refurb" plan, in which 7 million homes will be offered "whole house" upgrades with energy efficiency and micro-generation technologies by 2020, and every home by 2030. The aim is to virtually eliminate carbon emissions from UK homes. Ultimately, micro CHP may provide about 20 percent of the UK's electricity generation capacity, more than is currently obtained from nuclear power. As the UK is the largest market for gas boilers, with 15 million

## ► Alfa Laval's solution

### Efficient heat transfer

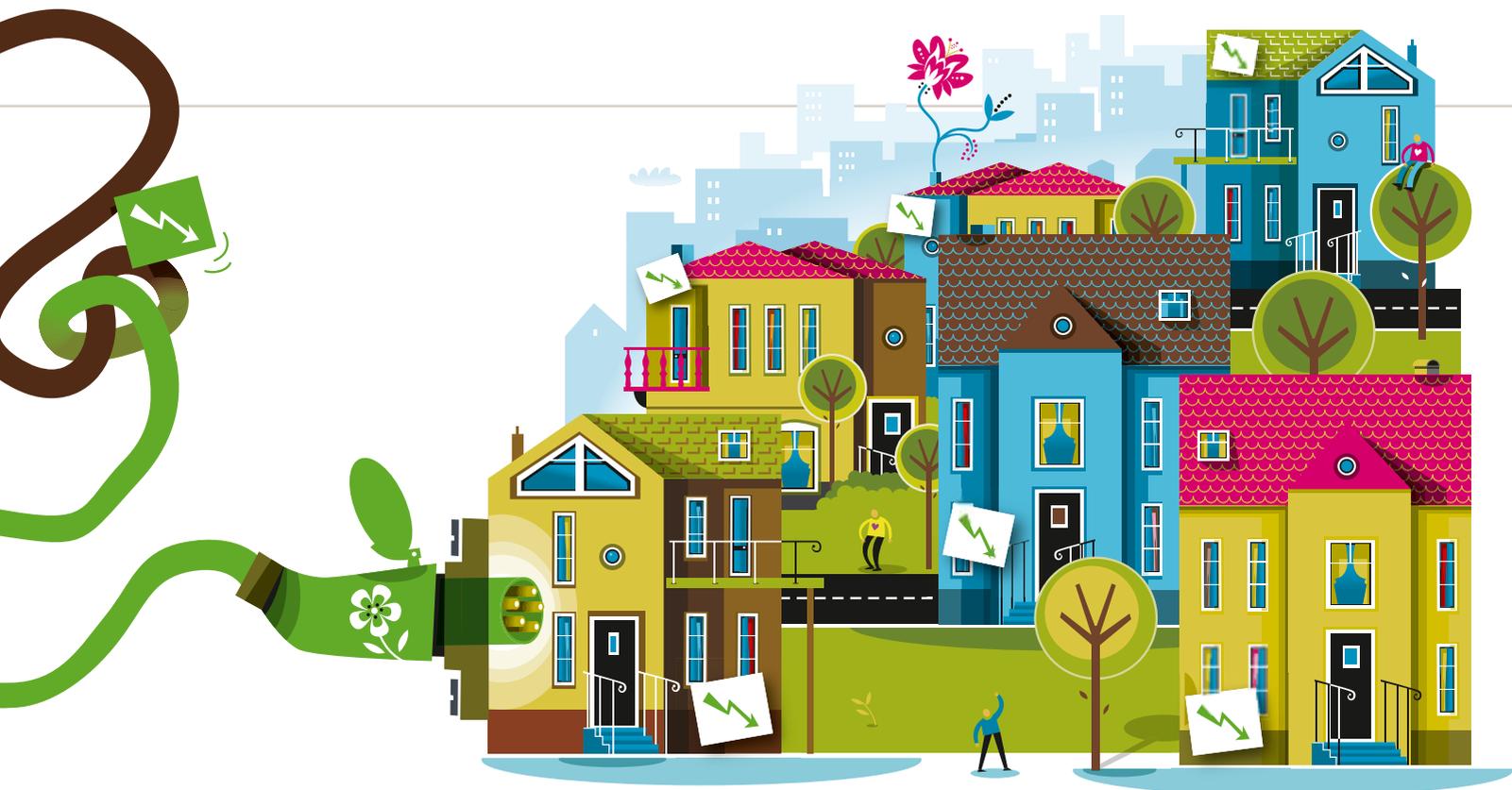
**Alfa Laval is** working with Energetix on the development of micro CHP using its Genlec® ORC (organic Rankine cycle) technology. This combines conventional gas boilers with a novel heat and power generation system based on conventional refrigeration technology.

The technology relies on efficient heat transfer, and here Alfa Laval is contributing with its innovative heat exchanger technology. Geoff Barker, head of marketing and sales at Energetix, notes, "Alfa Laval recognizes the potential of micro CHP, and the technical support has been invaluable."

Barker explains that the benefit of

his company's micro CHP is that, whilst the overall system is protected by international patents, "our technology uses widely available industrial components." Primarily these are based on small-scale and household refrigeration technologies. Compared with other micro-CHP technologies that rely on more complicated components, this reduces both manufacturing set-up and time to market.

"Five boiler manufacturers in Germany, the Netherlands, Italy and the UK are using our technology," says Barker. Products based on Genlec micro-CHP technology could be on the European market during 2010.



homes using gas, micro CHP is very attractive as a carbon-reduction technology.

**WITH MICRO CHP**, a household's carbon emissions can be typically cut by 5 to 10 percent, or between 200 and 800 kilograms annually, compared with a top-rated household condensing boiler with a large demand for heat. Barker points out that power utilities are also keen to support carbon-reduction technology as part of their own legal requirement to meet ever-lower emissions targets. Barker says that national electricity grids are looking to reduce

their "carbon intensity". One key measure is the amount of kilograms of carbon dioxide produced per kilowatt hour of electricity produced. In the UK, for example, the average figure is 0.58 kilograms per kilowatt hour, but the carbon intensity of micro CHP is less than half – only 0.24 kg/kWh. The UK has a high dependency on coal and oil for electricity generation, which increases its carbon intensity. Little wonder then that Europe's major boiler manufacturers and power utilities are eager to see this technology moved out of development and into homes as soon as possible. ■

► The micro-CHP technologies

## How the different technologies work

**In 2004, the first** micro-CHP units became available in the UK. Products are now available in Germany, the Netherlands, Japan and the United States.

In essence, the micro-CHP unit replaces a gas central heating boiler. It provides heat and hot water as usual, but additionally provides the majority of a home's electricity needs.

Conventional gas boilers cost between 500 and 2,500 euros and the average lifetime is 15 years; micro CHPs have a comparable lifetime and cost 1,000 to 2,000 euros more, but the higher value of electricity produced results in more energy efficiency and a lower carbon footprint.

Currently there are four

competing technologies based on the Stirling engine, ORC (organic Rankine cycle), internal combustion engine and fuel cell. Many companies are working with Stirling engines, and ORC technology is now close to entering the market. Fuel cells are still at the development phase, whilst internal combustion engine-based systems, such as Honda's Ecowill, have already sold thousands of units

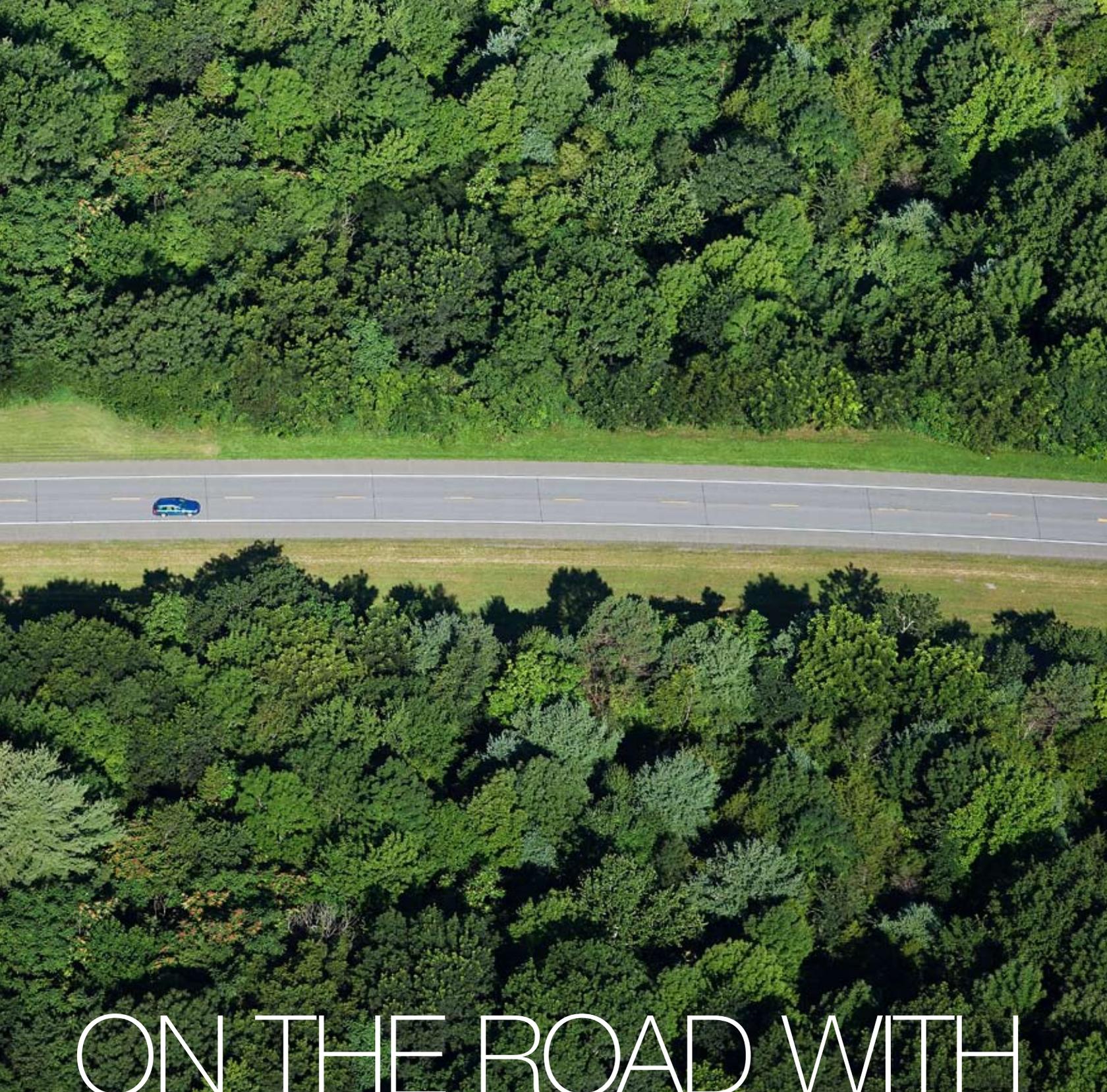
A Stirling engine is a heat engine that operates by cyclic compression and expansion of air or other gas (usually helium) at different temperature levels such that there is a net conversion of heat energy to mechanical work. The term "Stirling engine" refers

to a closed-cycle regenerative heat engine with a permanently gaseous working fluid.

In the Genlec ORC, a closed circuit organic Rankine cycle, the working fluid is evaporated indirectly by heat from the gas combustion chamber. Once evaporated, the working fluid then passes through an expander converting pressure energy into rotational energy, thus generating power from a small generator. The low-pressure vapour is then condensed in a plate heat exchanger, where it releases its heat to the heating circuit in the home. The condensed working fluid is then pumped to a higher pressure and continues around the circuit again.

In a fuel cell, the chemical energy within the fuel is converted directly into electricity (with by-products of heat and water) without any mechanical drive or generator. Fuel cells have begun to be developed specifically for micro-CHP applications and although large numbers of units are under trial in Japan, it is unlikely that commercially viable products will be available in Europe before 2012.

In overall efficiency terms, the Stirling engine and ORC-based micro CHP will be 88 to 90 percent efficient, comparable to high-efficiency condensing boilers, whereas fuel cells have a lower overall efficiency, achieving 85 percent at most.



# ON THE ROAD WITH **FRIENDLY FUELS**

**Cellulosic ethanol** looks to be the next major development in ethanol production. The Verenium Corporation, in conjunction with BP, is building a new plant in the United States to make the development a commercial reality. The first step is a state-of-the-art test refinery.

TEXT: MICHAEL GIUSTI PHOTOS: ED LALLO & GETTY IMAGES



**A MERE SIX MILES AWAY** from where W Scott Heywood discovered Louisiana's oil patch a century ago, scientists and engineers are working to commercialize what could be the next generation of motor fuel — cellulosic ethanol.

Unlike the traditional ethanol being produced across the globe, which is made mostly from sugar-rich food crops, cellulosic ethanol comes from woody, fibrous, inedible parts of plants.

Scientists have long struggled with converting cellulose into ethanol on a commercially viable scale. But that is just the process Verenum Corporation is working towards at its facility in Jennings in the US state of Louisiana.

The 1.4 million-gallon-per-year demonstration refinery is tucked into a landscape dotted with oil wells and surrounded by a sea of sugarcane farmland — an appropriate setting for the task of bridging the agriculture and petroleum worlds.

Working in small-batch “campaigns”, scientists at the facility are using a process that they plan to scale up to a commercial level by the end of 2012. And they have a powerful ally backing them — British oil giant, BP. Verenum has formed a joint venture with BP to build a massive cellulosic ethanol plant in South Florida, with plans to break ground this year.

But first, plenty of work still needs to be done at the Jennings test refinery. The primary goal of the facility, according to Carey Buckles, vice president of operations at Verenum, is to test different enzymes, microbes and pretreatments, with the ultimate goal of converting what are essentially piles of wood chips into motor fuel.

**ENVIRONMENTALISTS AND SUSTAINABILITY** fans have long sung the praises of ethanol, largely because it is made with home-grown resources and does not rely on fossil fuels.

Cellulosic ethanol has some other strategic benefits, according to Verenum, because the crops used to make cellulosic ethanol are generally not commodities used in other industries, such as food production. Company officials hope that, since they won't be competing with other industries that might have driven up commodity prices, their costs will be contained.

Verenum's three feedstocks of choice so far are energy cane, sugarcane bagasse and sorghum (see facts box on page 27). These feedstocks are ideal, Buckles says, because they have some very attractive traits.

According to Michael E Salassi, professor of agricultural economics for the Louisiana State University department of agricultural economics and agribusiness, crops such as energy cane are grown for their biomass rather than their sugar content. That means they often have lower production costs per acre while offering more biomass yield per acre.

Another benefit is that, with energy cane, farmers don't

#### ► Government push for biofuels



**US policy makers** are now looking to ethanol as one economical and environmentally friendly alternative to fossil fuels. The US Energy Independence and Security Act of 2007 calls for biofuels, and specifically non-food-based biofuels, to make up an increasingly large portion of the US energy portfolio.

The bill establishes a tiered quota, increasing to 36 billion gallons (136 billion litres) of renewable fuels to be used nationally by 2022. The bill mandates that 250 million gallons (946 million litres) of biofuels be used by 2011.

Programmes such as this are a nice boost to a young industry, says Carey Buckles, vice president of operations at Verenum.

Buckles believes, however, that cellulosic ethanol would have a future even without the government support.

“Don't get me wrong,” he says. “They are all good wind in our sails. But government spending will not solve the technical issues all by themselves. However, when you have policy behind you, it is a great momentum driver to help move you forward.”

**“That is the race — to find that best product and see who can build a commercial business out of it first.”**

**CAREY BUCKLES**, vice president of operations, Verenum

have to worry about traditional pests, Salassi says.

“With cane grown for its sugar, you have to contend with sugarcane borers, which would cause damage and affect the juice and sugar production,” he says. “With energy cane, you wouldn't be worried about that.”

Evaluating feedstocks is one of the primary missions of Verenum's test facility.

“And that is the race — to find that best product and see who can build a commercial business out of it first,” Buckles says.

So far, energy cane is the winner. Verenum officials estimate that once their process is scaled up to full commercial size, it will yield 1,800 gallons (6,814 litres) of ethanol per acre annually from energy cane, compared with about 650 gallons (2,460 litres) of conventionally produced ethanol from sugarcane in countries such as Brazil.

>>>



Dell Hummel, sales manager, Alfa Laval (left) with Carey Buckles, vice president of operations, Verenium

**“We are still doing research into ways to optimize the decanters and finding ways to improve separation and lower power requirements, ultimately reducing operating costs.”**

*DELL HUMMEL, sales manager, Alfa Laval*

>>> To strip sugars out of woody plants and grasses to make ethanol Verenium hauls in small mountains of already-ground feedstock. From there, the feedstock gets a steam and acid treatment to produce sugars. Verenium has been using an Alfa Laval NX 438 decanter centrifuge to separate the pentose sugars (sugars in solution) from the hexose sugars (sugars in solid form).

The pentose sugars are in a chain containing five carbon atoms; the hexose sugars are in a chain containing six carbon atoms. The different carbon structures call for different “digestion” treatments. To that end, engineers apply a custom mix of microorganisms and enzymes to each sugar stream, freeing those sugars to a more accessible form.

Those streams are then recombined in a tank called a “beer well”. The tank’s name is appropriate, because at that point, in a process very similar to brewing beer, yeast is applied, and the sugars are fermented to make the alcohol that will be distilled out as ethanol.

Verenium has also been using the Alfa Laval decanter for its original intended use – dewatering the solid lignins and fibres remaining after ethanol distillation. On a commercial scale, the dewatered solids discharged by the decanter

could potentially be burned to produce power for the ethanol plant.

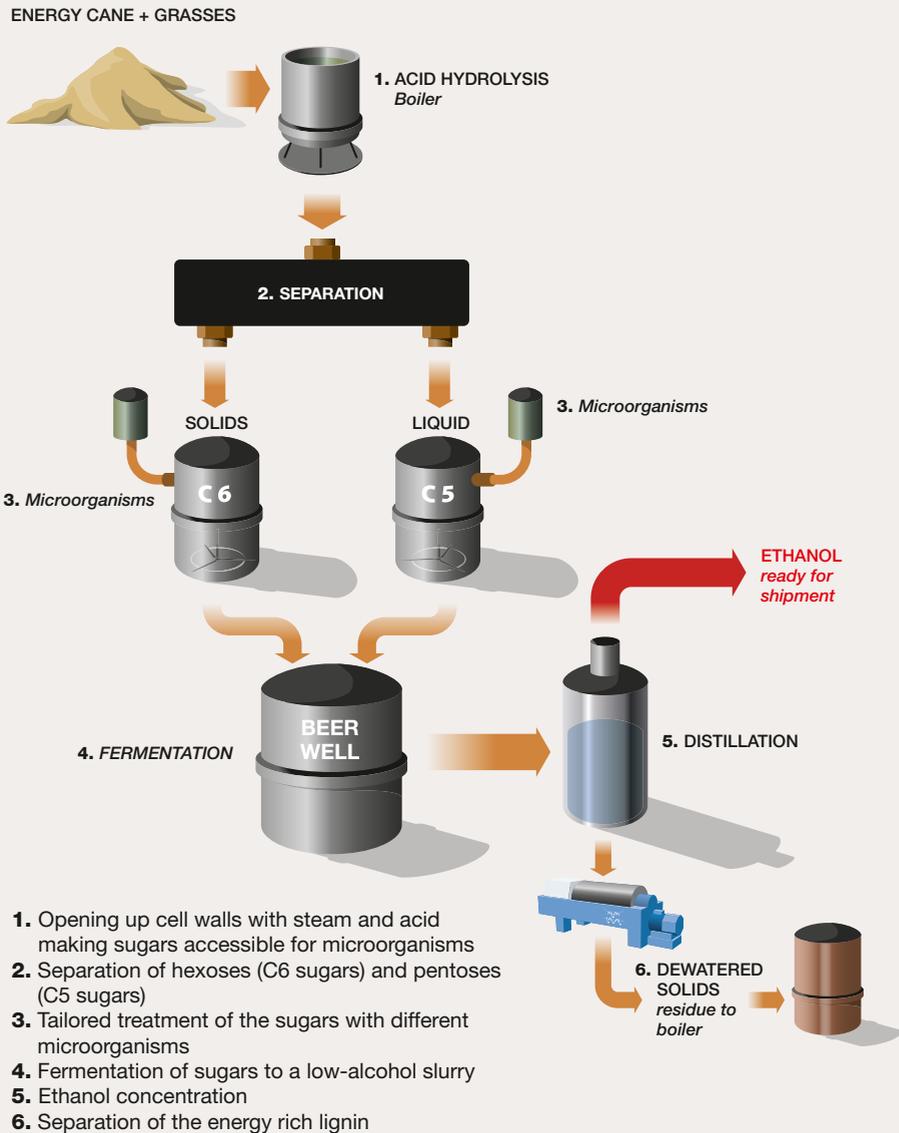
If all goes well, Vercipia Biofuels — BP and Verenium’s joint venture — will be churning out 36 million gallons (136 million litres) of cellulosic ethanol a year beginning in 2012. The companies have committed 45 million US dollars to the project and leased 36,000 acres of land in Highlands County, Florida. Verenium intends to use 20,000 acres of this, which is now lying fallow, to grow feedstock such as energy cane.

Construction of the facility is expected to cost nearly USD 300 million.

In February 2009, Verenium and BP submitted an application under the US Department of Energy’s loan guarantee programme. In June, the DOE invited them to the next phase of the process. If awarded, the loan guarantee could provide the companies with up to 80 percent of the debt funding necessary for the construction of the new facility.

Based on the data from the Jennings test facility, Verenium hopes to produce ethanol that will sell at the retail level of USD 2.10 per gallon — a price point that is competitive with traditional ethanol and with today’s petrol prices.

► Making cellulosic ethanol



## Technology partners

**When Verenium needed** to dewater the stillage at the end of its production stream, it looked to Alfa Laval and its decanter centrifuge.

That is because Alfa Laval has provided decanter centrifuges for stillage dewatering since the 1960s, says Dell Hummel, sales manager for Alfa Laval.

Most of those original machines were sold to potable (i.e., drinking) alcohol distilleries before 1980, he says.

But from 2001 to 2009, fuel ethanol saw a tenfold production expansion, opening up a growth market for Alfa Laval's decanters.

In that time, Alfa Laval sold more than 300 decanter centrifuges to ethanol manufacturers.

"Alfa Laval is the leading supplier of decanter centrifuges and plate-type heat exchangers to the US ethanol industry," Hummel says. Alfa Laval decanters are being used successfully for dewatering stillage at traditional ethanol plants across the industry. This is why, he says, Verenium believed it would be a good fit for its application.

According to Carey Buckles, vice president of operations at Verenium, Alfa Laval has been a model supplier when it comes to partnering on new and emerging technology. In addition to the decanter, Verenium and Alfa Laval have gone on to partner in other areas — specifically through a joint marketing agreement regarding the Purifine enzyme, which is designed for degumming vegetable oil. Too often, he says, other suppliers and vendors are unwilling to see the early relationships as a partnership and are often reluctant to work as hard to find solutions to shared problems.

For his part, Hummel stresses that Alfa Laval is excited to work with emerging technology partners such as Verenium.

"Our policy has been to get in the game early, because then they know our technology works, and when they scale up, we are there as a proven partner," he says.

One of the benefits of partnering with key suppliers such as Alfa Laval is that once the equipment is installed, the research and development doesn't end.

"We are still doing research into ways to optimize the decanters and finding ways to improve separation and lower power requirements, ultimately reducing operating costs," he says.

The key to the relationship is to be willing to communicate and work together, Buckles says, and be prepared for the challenges.

"New technology isn't for the faint of heart, weak of backbone or shallow of pocketbook," he says.

► Facts



### THE ENERGY SOURCES

- **Energy cane:** a tall plant in the sugarcane family bred specifically for ethanol production.
- **Bagasse:** a woody waste by-product from the sugar manufacturing process.
- **Sorghum:** (photo) a tall fibrous grass grown throughout the world for its grain, which is often used as an animal feed in the United States.

## New, bigger PureBallast

**Alfa Laval** has received an order from Samsung Heavy Industries on behalf of Stena Drilling Ltd., for PureBallast 2500. This is the largest PureBallast system to date, featuring a flow rate of 2500 m<sup>3</sup>/h.

PureBallast is Alfa Laval's unique and chemical-free system for ballast water treatment. It produces radicals that neutralize organisms in ballast water in a process that is efficient and self-contained, as well as harmless to the ballast tanks and crew. About 80 customers at shipyards in Europe, Asia and the Middle East have purchased PureBallast systems for their various types of vessels, including bulk carriers, dredgers, Ro-Ro and container vessels.

The 2500 system provides more than

double the capacity of any previous PureBallast version. It will be delivered to the arctic drillship Stena DrillMAX ICE in June 2010. This high-profile arctic drillship is the world's first dynamically positioned, dual-mast drillship with ice-class certification. It will handle sensitive applications in sensitive waters, meaning that nothing can be left to chance.

In September, Alfa Laval will launch yet another version of PureBallast – EX proof – at the SMM (Shipbuilding, Machinery & Marine Technology) International Trade Fair in Hamburg, Germany. With the EX version, Alfa Laval's PureBallast enters the market with a system suitable for tankers transporting explosive gas or liquids. ■

## Forging ahead

**Ingram Barge Company** is the leading carrier on the United States' inland waterways, with approximately 4,000 barges and 136 boats transporting commodities along the Mississippi River system and the Gulf Intracoastal Waterway. With its focus on "zero harm", the company works closely with Alfa Laval, improving processes with cost- and space- efficient solutions that support a sustainable environment.

One example of this was to completely revamp Ingram's fuel and lube-oil filtration and its heating and cooling systems onboard its boats. Ingram replaced the traditional shell-and-tube heat exchanger technology with Alfa Laval's compact plate heat exchangers, and it replaced its filter pots with Alfa Laval's Eliminator combination filter and Heron centrifuge.

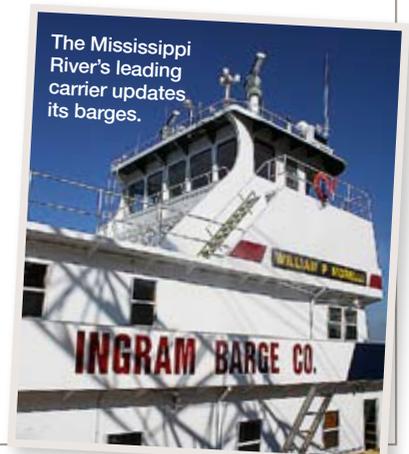
Ingram is planning on replacing the shells, tubes and filter pots on the remainder of its fleet. By doing this, the company is not only saving space, but it is also eliminating the need for filter disposal, which fits in well with Ingram's "zero harm to the environment" philosophy. It also allows Ingram to reallocate man-hours previously spent on cartridge filter disposal and maintenance to more productive activities.

"While there were upfront costs for the first installation, here we are now 1 million operator-hours down the road, and the payback is substantial", says Tom Smith, Ingram vice president vessel engineering. ■

For more on the Eliminator, view the OnDemand presentation: <http://www.brainshark.com/alfa/Eliminator>



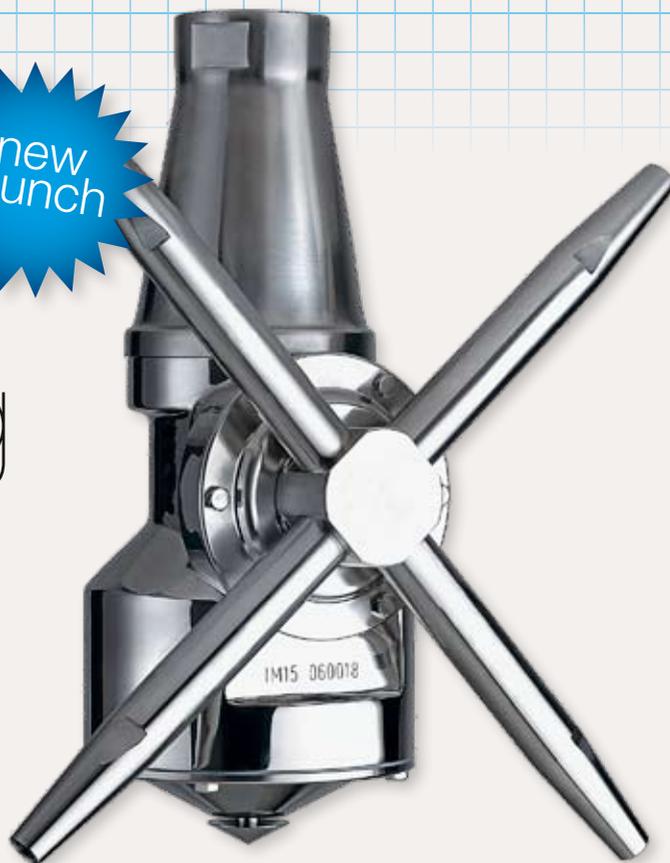
PureBallast has been adopted by a wide range of vessels, including arctic drillship Stena DrillMAX ICE.



The Mississippi River's leading carrier updates its barges.

LET US PRESENT:

# Alfa Laval Rotary jet mixing



## Multi-talented tank technology

**ALFA LAVAL ROTARY JET MIXER ISO-MIX** is the latest addition to Alfa Laval's tank equipment portfolio. The technology's versatility makes it nothing short of a tank-mixing revolution.

Luck has played a part in many of the greatest technology breakthroughs, and Alfa Laval rotary jet mixing is yet another example.

Originally developed for cleaning in place (CIP), its mixing skills came to light when a tank scheduled for cleaning was left full by mistake. The rotary jet head was discovered to be mixing the liquid – and doing a good job of it. Since then, its talents have been developed for a range of mixing applications.

The patented Iso-Mix rotary jet mixing technology provides faster and more efficient liquid mixing in tanks and is highly effective for gas and powder dispersion. Key applications include the brewing and soft drinks industries, but there are many other possible applications for the pharmaceutical, biotech and chemicals industries.

**THE TECHNOLOGY IS A PERFECT** fit to complete the tank equipment offering, says Rene Elgaard, market unit manager for Tank Equipment, Sanitary Equipment. "With the new rotary jet mixers, we now offer the best of both worlds," he says. "Alfa Laval is already world class in hygienically designed impeller agitators, due to a superior impeller design and a modular 'to fit the purpose' product range. Rotary jet mixing further strengthens our portfolio of mixing technologies."

The benefits are clear, Elgaard says. "In the brewing industry, for example, fermentation time can be cut from 14 days to just 10 by applying rotary jet mixing in the fermentation tank," he says. "The quality of the beer

also becomes more consistent. Another example is vegetable oil processing, where the rotary jet mixer can be used to disperse nitrogen. This lowers the oxygen content in cold-pressed oils and can increase shelf life by a whole year."

**ELGAARD SAYS THAT** rotary jet mixing can also mean considerable investment savings. "In the beverage industry, one tank with a rotary jet head installed can be used for multiple processes, including water de-aeration, syrup/aroma mixing, carbonation and even CIP if necessary he says. "These tasks are traditionally performed in separate process units."

The system is based around a circulation loop. Liquid is pumped from the bottom of the tank and injected into the bulk liquid through the nozzles of the mixer, which are positioned under the surface. The four jet nozzles rotate 360 degrees around both the horizontal and vertical axes. The double rotation ensures that the jets reach the entire volume of the tank, resulting in fast, efficient mixing, with the added benefit of low power consumption.

The technology is suitable for most tanks and reactor systems, from 100 litres to 100,000 cubic metres. "Rotary jet mixing allows for a much simpler tank design," Elgaard explains. "It also improves sanitary conditions, with no mechanical seals and no shaft penetrating the tank wall." ■

►► [www.alfalaval.com/rotaryjetmixer](http://www.alfalaval.com/rotaryjetmixer)

### Customer's voice

“ Installation of the rotary jet mixers in 5,000 hl fermenters at Carlsberg Fredericia brewery has increased fermentation capacity considerably, due to reduced fermentation and cooling times. The technology also provides added benefits such as more consistent fermentation times.”

**Peter Rasmussen**, plant and project manager, brew site, Carlsberg Fredericia Brewery



#### ► Facts

#### ISO-MIX ROTARY JET MIXER BENEFITS

- Allows highly efficient liquid mixing, powder mixing, de-aeration and gas dispersion
- Achieves multiple processes in one tank, saving on investment costs
- Simplifies tank design
- Enables more cost-effective plant design
- Improves sanitary conditions (requires no mechanical seals or rotating shaft penetrating the tank wall)
- Can be used for CIP
- No reactor loads (construction without either dynamic loads from the vibrations of the propeller or static loads from the weight of the mixer on top of the tank).

# Hot water with a clean conscience

**CO<sub>2</sub> heat pump water heaters** are helping Japan to reduce its CO<sub>2</sub> footprint and its citizens to cut energy costs. And with clean energy high up on everyone's agenda, the rest of the world looks set to take the plunge.

TEXT: PAUL REDSTONE PHOTO: GETTY IMAGES

**IT'S NO SECRET** that the Japanese love a nice hot bath. So much so, in fact, that water heating accounts for close to 30 percent of Japan's total domestic energy consumption and has a significant impact on the country's ability to meet its obligations under the Kyoto Protocol. In response, Japan has come up with the CO<sub>2</sub> heat pump water heater – a solution that can significantly reduce a household's energy consumption and CO<sub>2</sub> output.

The solution comprises a heat pump and a hot-water storage unit. What makes it special is the use of CO<sub>2</sub> as a refrigerant. Known as a natural coolant, CO<sub>2</sub> has a lower GWP (global warming potential) factor than traditional CFC refrigerants. It's also an excellent way to recycle a common waste product.

The Japanese government is a strong believer in CO<sub>2</sub> heat pumps and sees them as an important contribution to fulfilling its Kyoto Protocol obligations, under which the country must achieve a 6 percent reduction in CO<sub>2</sub> emissions, compared with 1990/91 levels, over the next five years. The government is providing grants to

help householders purchase CO<sub>2</sub> heat pump water heaters, with the goal of installing 5.2 million units by the start of the 2010 fiscal year. With this programme implemented, Japan will have achieved more than 10 percent of its total goal for CO<sub>2</sub> emissions reduction by 2018.

But interest is quickly spreading beyond Japan, and more than 600,000 units have already been sold in Europe.

There is enormous global market potential as demands for efficient energy increase and CO<sub>2</sub> emissions requirements become ever more stringent.

**WATER CAN BE** heated to 90 degrees Celsius, with an energy saving of around 65 percent compared with conventional electric water heaters. It's also around 80 percent cheaper to heat water this way than to use Japan's town gas system. What's more, by not burning fossil fuels to heat water, CO<sub>2</sub> emissions from water heating can be halved.

A CO<sub>2</sub> heat pump water heater comprises a heat pump and a hot-water storage unit. The components are connected in series, and the CO<sub>2</sub> gas refrigerant circulates around the system. The system derives two units of energy from ambient air temperature for every unit of electrical power used, but more than three units of hot water energy are produced as a result.

Energy for the refrigerant is collected from the external air via a heat exchanger. A centrifugal fan is generally used to provide air flow. The CO<sub>2</sub> is heated to around 100 degrees Celsius under pressure of 10 MPa using a gas compressor, at which point it becomes a supercritical fluid. Energy from the heated refrigerant is then transferred into water via a heat exchanger, resulting in hot water. Water temperatures around 5 degrees Celsius and up are suitable at this stage. Ejector or expansion valves are used to reduce pressure on the refrigerant, allowing it to cool and revert to CO<sub>2</sub> gas.

Some 25 companies currently manufacture CO<sub>2</sub> heat pump water heaters in Japan, where the installed base had reached 2 million at the end of October 2009. Many are now planning to launch their units in Europe and the rest of the world. ■

## ► Facts

### JAPAN WARMS UP

- Tap water heating accounts for 30 percent of the total energy requirement.
- CO<sub>2</sub> heat pumps produce 50 percent less CO<sub>2</sub> emissions.
- The Japanese government subsidizes CO<sub>2</sub> heat pumps.
- 500,000 units were sold in Japan in 2008.
- Japanese households can save about USD 15 on their monthly electricity bill.



With the CO<sub>2</sub> heat pump water heater, water can be heated to 90 degrees Celsius, with an energy saving of around 65 percent compared with conventional electric water heaters.

► Alfa Laval's solution

## A wider market

**Alfa Laval's key** product for the CO<sub>2</sub> heat pump water heater market is the APX10 brazed plate heat exchanger. It's ideal for this price- and space-conscious market, where it can replace larger, more complicated and more expensive heat exchangers.

But Peter Nobel, general manager of the OEM Segment & Business Centre BHE, says the market for CO<sub>2</sub> heat pump water heaters is just one slice of a larger pie.

"It's a very big market in Japan, and potentially in Europe and the US, where more energy-efficient new house constructions offer potential for CO<sub>2</sub> heat pumps," he says. "But there are wider applications for CO<sub>2</sub>-related products. We are developing heat exchangers for CO<sub>2</sub> applications that can handle larger capacities, and there is interest from the market. Applications include refrigerated transport and refrigeration systems for supermarkets."

Development of these applications, Nobel says, is likely to be fuelled by political pressure to reduce the environmental impact.

Nobel says Alfa Laval has a great deal to contribute in this area.

"We have in-depth knowledge of heat transfer and provide extensive service and support around the application," he says. "We also have a lot of experience in design work and prototyping."

# THE PUREST OF FRUIT

**Alfa Laval's Foodec decanters** bring relief to puree and juice producers struggling to eliminate the black specks in their mango products.

TEXT: ANNA McQUEEN PHOTOS: GETTY IMAGES

**WHO COULD SAY NO TO A MANGO?** With its divine colour, fragrant aroma and succulent flesh, the mango tempts even the fussiest of eaters. Although the mango only arrived in Europe in the 1800s, after the British colonization of India, it is one of the oldest cultivated fruits in Asia, with a history going back some 4,000 years.

India, where the mango in all its many varieties is the national fruit, is the world's largest producer of mangoes with a production of 12 million tonnes in 2009, half of the total world production of 24.4 million tonnes (source: FAO), yet it accounts for under one percent of the global mango trade. This minimal export is in part due to the huge domestic mango market, but with international demand for mangoes growing, the Indian agricultural sector, which

employs more than 60 percent of the country's workforce, is seeing an opportunity to develop the export potential of this most popular fruit.

**THE CHALLENGES** to the consistent production of mango puree and juice commodities include periodical climatic problems such as hurricanes and flooding as well as neglect in orchard management and irregular bearing tendencies (the tendency for mango trees to bear a heavy crop one year and little or no crop the

following year) in commercial varieties. But one constant problem shared by all mango juice and puree producers is the issue of tiny black specks in the product.

The black specks found in mango juice are caused by a number of factors ranging from blemishes on the surface of the fruit to fragments of pits, insects in the mango pits and particles left in the juice from the mango stems. Although these black specks are perfectly natural, juice and puree producers are clearly aiming to sell the best-looking fruit products they can, so it is desirable to remove as many specks as possible. This is where Alfa Laval steps in with its range of Foodec decanters.

**ALFA LAVAL'S FOODEC DECANTERS** can easily be incorporated into existing production lines, where they enter the process after the fresh mangoes have been washed, brushed and sorted, peeled and de-stoned, refined and sterilized, and then packed in aseptic bag-in-drum packaging. The decanters have a grooved bowl with a steep cone to decant the pulp or puree and to remove any foreign bodies, and tests have shown significant improvements in black speck reduction.

A speck rate of three per 10 grams of juice or puree is considered acceptable, but Alfa Laval's Foodec decanters have reduced this to a barely perceptible two specks per 10 grams for the 75 percent of Indian mango puree producers who have moved over to this technology.

In southern India, Rassa Food Ltd, one of India's leading mango juice and pulp producers, acquired an Alfa Laval Foodec decanter in 2009. "We are extremely happy with our purchase, and it has made a big difference to our products," says Ramana Reddy, managing director of Rassa Foods. "Currently we are turning out some 7,000 tonnes of mango pulp annually with one line. We're planning to add another line in 2010 and will certainly be adding another Foodec decanter to it."

"Some of our clients had been losing up to half their

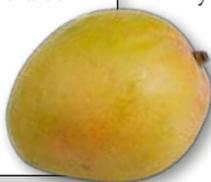
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## ► Facts

### MAGICAL MANGO

Mangoes are a valuable contribution to the diet. They are high in fibre, vitamins A, B6, K and C and polyphenols, which may reduce the risk of cardiovascular disease and cancer. They are also a rich source of other essential nutrients, such as potassium, copper, iron, selenium and amino acids. Mango peel and pulp also contains valuable antioxidants and polyunsaturated fatty acids.

In Chinese medicine, mangoes are used to treat poor digestion, anaemia, bleeding gums, coughs, fever and nausea.





India's national fruit being unloaded at the Gaddianaram fruit market in Kothapet, India.



► Facts

## INDIA'S FRUIT INDUSTRY

- India accounts for 10 percent of world fruit production (source: Agribusiness Information Centre) and is the world's largest producer of mangoes.
- Indian mango production is estimated at around 12 million tonnes annually
- Despite being a major food producer, India's share in the world food trade is still less than 2 percent, and it currently accounts for less than 1 percent of the global mango trade.
- India's Prime Minister Manmohan Singh has called for a new National Food Processing Policy to encourage rapid growth in the food-processing sector and promote technological innovation. The goal is to increase India's share in the global processed food trade to 3 percent by 2015.

**“We’re seeing more business due to the significant reduction of brown and black specks in our mango pulp, so we’re very happy with our decanter.”**

**MEHUL H MARU**, *managing director of Lion Group.*

>>> harvest because they had more than the maximum three specks per 10 grams in their mango-based products,” explains Tom Thane Nielsen, communication manager for food technology at Alfa Laval. “Our Foodec decanters create a turbulence in the rotation that separates solids from liquids, making this technology the best solution for this processing requirement.”

Fruit pulp producer Lion Group based in the eastern part of the country, is another satisfied Foodec client. “We’re seeing more business due to the significant reduction of brown and black specks in our mango pulp, so we’re very happy with our decanter,” says Managing Director Mehul H Maru. Lion Group produces around 3,000 tonnes of mango puree every year, mainly from Kesar and Alphonso varieties. “The service we have received has been extremely good, and the decanter is very reliable, meaning we can offer continuous production,” he says.

Indeed, the success of the Alfa Laval Foodec solution is such that orders are flooding in from Indian mango puree

and juice producers. “Our Foodec decanters have simply to be fine-tuned into the existing mango production line, with flow speeds and bowl rotation adjusted to suit the variety of mango being processed. Customers who have acquired them are delighted, as fewer specks mean higher prices and a much cleaner product than before,” says Thane Nielsen. “Compared with other technologies for speck removal, the Foodec decanter is the most suitable and unique solution on the market today. It is also a very cost-effective solution with a very short pay-back time.” ■

► Alfa Laval's solution

## From harvest to sale

**Raw fruit arrives** at the production line, where it is washed, brushed and inspected for any blemished or unripe fruits. Machines are used to peel, de-stone and extract the pulp.

The resulting mash is heated to 80–95 degrees Celsius for maximum yield extraction, then refined and put through the Foodec decanter for speck removal. The juice can then be concentrated in an evaporator before being sterilized and aseptically packaged.

Alfa Laval Foodec decanters have an optional “complete purge enable” system that blankets the product with a protective gas and prevents air from entering the chamber and thus oxidizing the pulp or juice.

Through larger and more consistent yields of juices and purees with improved quality, sales can be increased. Thus the cost of the investment in a decanter can normally be paid back in one production season.

# THE ART OF CONTINUOUS FLOW

**ART Plate Reactor** gives AstraZeneca flexibility



PHOTO: SAMIR SOUDAH

**FOUR QUESTIONS FOR ANNA STENEMYR**, team manager, AstraZeneca R&D Process Chemistry, who appreciates the advantages with the Alfa Laval ART plate technology.

**Why did you invest in continuous flow chemistry?**

“This technology is fairly new for the pharmaceutical industry, so we started by cooperating with Alfa Laval to evaluate its new ART Plate Reactor. We found it to be a multi-purpose unit that gave us the flexibility we were looking for, along with many other advantages over using batch reactors.”

**What are those other advantages you speak of?**

“There are many, but I would say that by using the plate reactor we get a unique cooling capacity compared with batch reactors. The plate reactor can absorb an enormous amount of heat and remove it from the reaction, which is not possible in a batch reactor. When using batch you usually use an excess of reactants to make sure that the reaction gets completed, but in continuous flow reactors, since you mix the compounds instantly, you can avoid this. An outcome of this can be cleaner reactions – for example, less formation of unwanted side products. In summary, these advantages usually give an increased yield and a better, safer and more effective process.”

**You've been working with it for over a year now. Are you happy with the results you've seen so far?**

“We are still exploring and finding new applications, but we are definitely satisfied so far. One case comes to mind: We had a compound that was very rich in energy, and we knew we couldn't use our batch reactors for this process for safety reasons. An earlier option would have been to outsource this, but with the plate reactor we can now perform this chemistry in-house, using continuous flow technology. This saves us time and money.”

**Why did you choose the Alfa Laval ART Plate Reactor over other products?**

“The flexibility it gives us is very important. We can put in a wide range of chemical reactions, and it has both cooling and heating capabilities. In addition it has a variety of reaction channel sizes, and we can use a broad range of flow rates. There are several points for insertion and removing samples, and we can monitor the reaction. Also, it's easy to take apart and clean. Not many competitors offer this flexibility. So we will definitely continue to use this technology. I see continuous flow technology growing in the pharmaceutical industry in the future.” ■

►► [www.alfalaval.com/artplatereactor](http://www.alfalaval.com/artplatereactor)

# An ocean of challenges



Clean water.

Today, more than one billion people lack access to clean water. If we fail to conserve this life-giving resource, the numbers suffering from thirst will increase dramatically.

At Alfa Laval we are deeply involved in this challenge. We convert seawater to freshwater. We cool and heat water. We clean wastewater. Our high performance decanters play a key role on the global stage. Installed in their thousands throughout the world, they clean a volume of wastewater from a population equalling that of the entire USA. And each year we install new decanters with sufficient capacity to match the needs of everyone in Sweden!



[www.alfalaval.com](http://www.alfalaval.com)