PHOTO: IVANHOE ENERGY

Ivanhoe Energy is testing a field upgrading technology in Bakersfield, California.

Many in situ bitumen producers face a challenge—how to recapture the margin they lose on the price differential between heavy and light oil. In a report commissioned by the Alberta government, economist Pedro van Meurs confirmed the reason behind the issue: "Upgrading is a very important method to create additional value for the investor. About half the value of integrated projects is attributable to upgrading."

For in situ producers that lack the economies of scale of oilsands mines to build traditional large-sized upgraders, a new option may soon become available—the small-scale "field upgrader."

A handful of companies are working on different versions of a similar concept: an upgrader that would enable producers to transport lower volumes of a higher end product from the field, thus allowing them to avoid the cost of diluent and to boost their bottom line.

Most small-scale upgraders would run on a feed of between 10,000 to 30,000 barrels a day.

Currently, at least four such field upgraders are in various phases of testing or commercialization. They include projects being built by Ivanhoe Energy, Genoil, ETX Systems, and Chattanooga Group. In this article we look at the first three, including milestones each has completed in its development.

SMALL TECHNOLOGY

A look at three up-and-coming field upgrading systems

by Andrea W. Lorenz

The projects' builders tend to follow the same basic incremental steps: develop the concept, build a mini-version of the upgrader for pilot testing; test the unit with a variety of feedstocks; obtain funding for the next phase; complete a front end engineering and design (FEED) study; build a commercial model.

In each case, a certain amount of customizing is required. Each slate of crude oil has different properties, and has to be processed differently. Genoil chief operating officer James Runyan puts it this way: "Each upgrader has to be designed specifically for the crude you're trying to run. It's not one size fits all. That's the nature of the source."

THE ETX SYSTEMS UPGRADING PROCESS

ETX Systems was founded by Gerard Monaghan, its chief executive officer, and Wayne Brown, its chief operating officer.

Monaghan, a former Syncrude engineer with expertise in fluid coking, is the lead developer of the company's upgrading concept. Brown, also a former Syncrude engineer, taught chemical engineering at McGill University before joining the team.

ETX is currently operating a pilot unit located in the National Centre for Upgrading Technology (NCUT) in Devon, Alberta. The unit produces one barrel of oil per day.

"The project should give us yield and qualities by November," says Brown.

The ETX upgrading process is a thermal process that does not involve hydrogen addition. In the technology, solid particles (coke or sand) are introduced into a reactor. Pitch is sprayed onto the particles, where the energy in the solids initiates the cracking reactions. After exiting the reactor, the solids particles are sent to a burner where the coke is consumed to reheat the solids. The balance of the coke is consumed to produce steam to offset the cost of an important energy source such as natural gas.

The key to the technology is that the products are collected perpendicular to the flow of solids. With this configuration, the reactor can be designed to provide a 30-second residence required for complete reaction of the heavy feed. ETX says this increases both the volume of the yield and the quality of the product.

Brown says that the reactor design virtually eliminates short-circuiting of the feed, resulting in a dramatic reduction in the required reactor size.

"The reactor decouples the gas and solids residence time and allows optimization of these processes. It also allows a lower reactor temperature to be used," says Theo de Bruijn, a researcher with NCUT.

The ETX team is working toward a goal of building a $100-million demonstration unit by 2012. To achieve construction of the D-500 unit, as they have dubbed it, they need a partner.

"We need an entity to provide the bitumen on an ongoing basis," Brown says.

PHOTO: GENOIL

Genoil has a testing facility in Two Hills, Alberta.

The final step is to build a commercial unit that will produce up to 30,000 barrels per day.

The company describes the heart of its process as the ETX reactor, a cross-flow fluidized bed. "Cross-flow fluidization is a well-established

ETX MILESTONES

1999	2005	2006	2007
Envision Technologies Corporation is founded by Gerard Monaghan, Wayne Brown, and two principal investors to develop the upgrading technology.	The company completes its front-end development activities and receives patent protection.	ETX Systems is spun out as a new entity.	Feed is introduced into the D-1 pilot plant.

GENOIL MILESTONES

2005	2006	2007
Genoil signs a letter of intent with Surge Global Energy to build a 10,000-barrel-per-day hydroconversion upgrader at Surge's Sawn Lake heavy oil development in Alberta.	Genoil signs a memorandum of understanding with Steaua Romana Refinery in Romania for a 1,500-barrel-per-day residue upgrader retrofit that will allow the refiner to increase input capacity by 5,000 barrels per day. (The refiner currently has no place to store the large volume of residue it currently produces.)	Genoil and Hebei Zhongjie Petrochemical Group sign a letter of intent to jointly build a major heavy oil hydroconversion upgrader in China. Genoil starts testing heavy oil samples at its pilot plant in Two Hills, Alberta. Genoil completes a successful test run of Hebei Zhongjie heavy crude and residual blend.

IVANHOE ENERGY MILESTONES

1980s	1998	1998-2002	2003-2004	2005	2006	2007
Ensyn Engineering develops and commercializes HTL upgrading technology converting biomass to liquids for the production of fuels and chemicals. Seven commercial plants using the technology to process biomass are in operation in the United States and Canada today.	Ensyn signs development agreement with Gulf Canada Resources and constructs a 20-barrel-per-day petroleum pilot plant in Ottawa.	Over 90 pilot plant runs are carried out on heavy oil and bitumen feed from Athabasca, Orinoco, and Venezuela.	A 1,000-barrel-per-day commercial demonstration facility is built in California to validate pilot plant data on a larger scale.	Ivanhoe Energy acquires 100 per cent of the HTL technology for petroleum applications. A preliminary design package is prepared by Colt Engineering.	AMEC is appointed tier 1 contractor.	Commercial demonstration plant successfully completes test run with Athabasca bitumen, pursuant to a longstanding agreement with ConocoPhillips Canada. Basic design engineering for a 10,000- to 15,000-barrel-per-day, full-scale HTL facility commences with AMEC. Commercial discussions with resource owners reportedly accelerated.

commercial fluidization process that has found utility in the drying industry, where the time that the fluidized particles spend in the dryer is critical," ETX explains. "In cross-flow fluidization, the solids move with a bulk velocity that is perpendicular to the flow of fluidizing gas."

The ETX upgrader has been under development since 1999. To achieve commerciality, the company is focused on three main activities: the one barrel per day pilot plant; a nominal 2,000 barrel per day commercial demonstration; and the commercial 20,000 to 30,000 barrel per day design.

THE GENOIL HYDROCONVERSION UPGRADER (GHU)

The model on which Genoil has based its technology was first conceived in the 1960s. Genoil's unit is designed to upgrade heavy crude and bitumen as well as refinery residue streams. It also hydroprocesses naphtha, kerosene, diesel, and vacuum gas oil. While Ivanhoe and ETX Systems use sand as a catalyst in their reactors, Genoil uses manufactured catalyst in its reactors.

Through adding hydrogen to the feed, then processing in a reactor using catalysts, Genoil says the method achieves an output of 100 to 104 per cent of the initial feedstock and an API increase of up to 16 degrees.

Chief operating officer and senior vice-president James Runyan adds that the result includes "desulphurization above 95 per cent, denitrogenation above 60 per cent, and demetallization above 95 per cent."

Early on in the development of Genoil's technology, Gulf Canada invested in its progress (Gulf also invested in the development of Ivanhoe's technology). In recent years, under the guidance of the New York City-based financier David Lifschultz, Genoil purchased the interest owned by Gulf Canada (now ConocoPhillips Canada) and took it to the next stage of development.

In 2001, Genoil built a mini-upgrader in Two Hills, Alberta, north of Edmonton, to begin testing its technology on various crude oil assays. Runyan describes the unit as a miniature version of the full size unit with capacity for 1 to 10 barrels per day. The engineering team has tested Athabasca bitumen, Canadian and Russian heavy crude refinery residual oils, and is currently operating the plant on a blend of Chinese heavy crude and residual oil.

Runyan says that to date the longest test run the company has conducted is 90 days. He explains, "Clients ship oil to us in drums. We ask for at least 100 barrels. It's trucked in and clients pay for the testing."

To date, Genoil has conducted pilot plant tests on a variety of feedstocks ranging from 8.5 to 22.5 degrees API gravity with sulphur contents as high as 5.5 per cent. The company says that "with the addition of a distillation unit after the GHU and using the residue to feed a syntheses gas unit, the API can be increased again as the tower bottoms are pulled off. The remaining product is an upgraded bottomless barrel ready for shipment to the refinery."

Runyan is eager to talk about the tests Genoil is conducting for Hebei Zhongjie Petrochemical Group Co. Ltd. in China. In October last year, Genoil and Hebei Zhongjie signed a letter of intent to build what they say will be the first major heavy oil hydroconversion upgrader in China. The Chinese partner has put up $20 million so far, while a third party will provide the balance of the $100 million needed to build the adjunct upgrader.

"As we speak, we're testing a Chinese heavy oil called M180 and resid oil or vacuum tower bottoms," says Runyan. Genoil's unit is to be built alongside the Chinese refinery.

The refinery must either buy or produce hydrogen, a key component of its process. Part of the upfront expense is incurred when a gasifier is installed to produce syntheses gas. Runyan says the cost of producing hydrogen using residue gasification is currently about $2 to $3 per barrel.

As for the inevitable problem of sulphur, Runyan says, "Sulphur and nitrogen in a refinery will kill your catalyst. We do desulphurize. We will have a sulphur recovery plant."

A handful of companies are working on different versions of a similar concept: an upgrader that would enable producers to transport lower volumes of a higher-end product directly from the field.

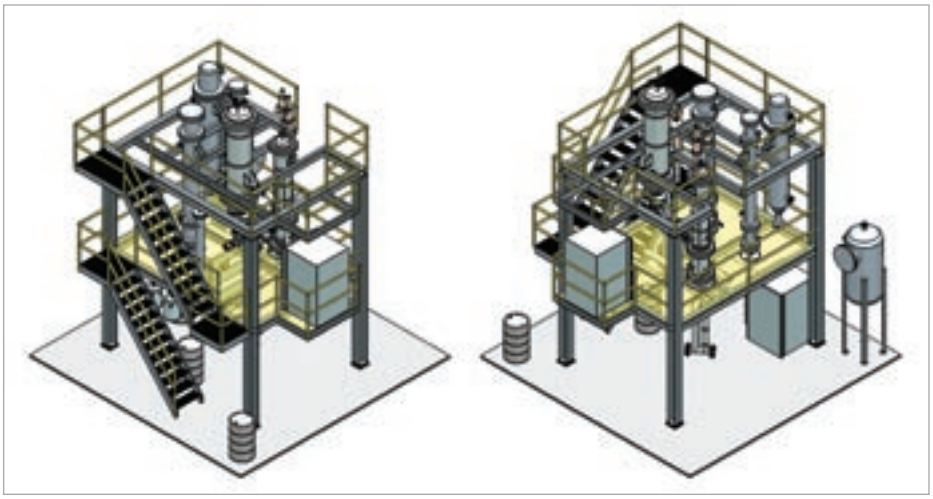

PHOTO: ETX

The design of the ETX pilot upgrader.

The next step in the partnership with Hebei Zhongjie is to complete the front end engineering and design study with a target start-up date of early 2010.

Genoil has been awarded a U.S. patent and is awaiting its Canadian patent.

THE IVANHOE ENERGY HEAVY TO LIGHT OIL UPGRADER

Ivanhoe Energy's technology is called the heavy to light oil (HTL) upgrader. The company has developed this technology through the pilot phase (20 barrels per day) and the commercial demonstration phase (1,000 barrels per day), and is now embarking on full commercial deployment. It expects its first commercial facility to be in the range of 10,000 to 15,000 barrels per day.

The company is currently in discussions with owners regarding the acquisition of heavy oil resources and/or the establishment of joint ventures where the HTL process would be used to develop the resource. The Canadian oilsands is a prime focus of these discussions, although Ivanhoe is also evaluating opportunities in Latin America, the Middle East, and elsewhere.

The HTL technology processes heavy oil in the field to produce a transportable, higher-value product than pure bitumen. Coke byproduct is used to produce on-site energy that can be used to generate steam or electricity, thereby freeing the producer from natural gas for steam generation.

HTL represents a simplified version of fluid catalytic cracking (FCC), which is used in many refineries around the world today. The mechanical similarities of the HTL process to FCC is an important factor that Ivanhoe says simplifies and reduces the risk in the design and engineering of full-scale HTL facilities.

While FCC circulates catalyst in a closed loop to convert crude oils to transportation fuels, HTL circulates common sand between key vessels to convert heavy oil to a lighter, more valuable product.

In the core HTL process, a closed loop of sand travels between a reheater that regenerates and heats the sand, and a reactor, where sand and feedstock make contact and the oil is upgraded.

The rapid thermal impact in the reactor promotes effective heat transfer and breaks apart the long hydrocarbon chains, vaporizing the feedstock. In the process, a thin film of coke is deposited on the sand grains.

Coked sand, oil vapours, and carrier gas exit the top of the reactor tower and are separated with a conventional cyclone. The vapors are immediately cooled or quenched into a light upgraded liquid product.

The coked sand is returned to the reheater, where the thin layer of coke on the sand is combusted, providing a valuable source of on-site energy that can be used to generate high-pressure steam or power. Additional byproduct energy is available from hydrocarbon gases that are not quenched to a liquid in the product fractionation unit.

In front of the core processing section, conventional distillation separates the heavy from the light fractions of the raw feedstock. The lighter, more desirable fractions are sent around the thermal process to preserve value and reduce equipment sizing, and the heavy fractions are heated and sent through the core process for upgrading.

The back end of the process consists of standard equipment deployed to clean up emissions generated from combusting the coke on the sand in the reheater. The ash, spent sorbent, and sand fines are collected for disposal as a non-hazardous solid waste.

At the company's demonstration plant in Bakersfield, California, the longest continuous feed run has been at its design rate of approximately two days.

Ivanhoe Energy believes this technology is a competitive alternative for the development of larger resources, but the initial focus is on the sub 75,000 barrels per day potential resources where the company says HTL provides a unique competitive advantage.

Ivanhoe Energy has appointed AMEC as its tier 1 contractor for the basic engineering of its HTL facilities. AMEC has completed certain preliminary design work, and will be accelerating this work once a resource deal has been completed. OSR

Upgrading basics

Upgrading is the process that changes bitumen into synthetic crude oil. Bitumen, like crude oil, is a complex mixture of chemicals (a hydrocarbon with chains in excess of 2,000 molecules). It also has a lot of carbon in relation to hydrogen. Some upgrading processes remove carbon, while others add hydrogen or change molecular structures. Some of these products can be used as is. Others become raw materials for further processing.

There are four main steps to the upgrading process: thermal conversion, catalytic conversion, distillation, and hydrotreating. The purpose of upgrading is to separate the light and convert the heavy components of bitumen into a refineable product. Different companies use these processes in different ways and at different stages in the transformation of bitumen into crude oil, but the principles behind this transformation remain the same.

SOURCE: OIL SANDS DISCOVERY CENTRE