Enhanced oil recovery research lab targets stranded reserves

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Rituraj Borgohain, a UW research scientist, works in the Enhanced Oil Recovery Research Laboratory, located in the Energy Innovation Center.

Tens of billions of barrels of oil remain stranded in aging fields in Wyoming's Big Horn, Wind River and Powder River basins, according to David Mohrbacher, director of the University of Wyoming's Enhanced Oil Recovery Institute (EORI). A portion of this stranded oil, between 1 billion and 3 billion barrels, can be recovered at today's oil prices using enhanced oil recovery techniques.

Mohrbacher expects the new Enhanced Oil Recovery Research Laboratory in UW's Energy Innovation Center to help small oil operators in Wyoming retrieve 5 percent to 15 percent of the state's stranded oil through enhanced recovery methods that include the use of carbon dioxide, surfactants (soaps) and polymers/gels to flood reservoirs where

oil is trapped and difficult to reach.

"What this finally allows us to do is sustain development in Wyoming oil fields through the ups and downs experienced by the oil industry," Mohrbacher says of the new lab. "And we do it in a very cost-effective way. We're the only organization that's going to look at solving many of the technical challenges faced by small Wyoming operators for development of oil fields that have produced for more than 50 years."

Enhanced oil recovery is a term used for techniques used to increase the amount of crude oil that can be extracted from existing oil fields or reservoirs after water flooding is completed. Current techniques include injection of chemicals, microbes, carbon dioxide, nitrogen, methane or steam. Carbon dioxide injection is the most common form of enhanced oil recovery used in Wyoming.

Approximately 14 percent of Wyoming's oil was produced using carbon dioxide enhanced oil recovery during 2011, and production using this EOR method will increase as several new floods are initiated during the next few years, Mohrbacher says. Natural gas or nitrogen also can be injected into the petroleum reservoirs to recover stranded oil.

Enhanced oil recovery takes place at existing oil fields that are producing greater than 97 percent water and a little oil, according to Mohrbacher. Use of enhanced oil recovery can increase oil production and extend the commercial life of the field by 20-30 years, Mohrbacher says.

Because infrastructure at these older fields already exists, there is a wide swath—when the price of oil ranges from $50 a barrel to $100 a barrel—of economic feasibility to pursue enhanced oil recovery, Mohrbacher says.

More enhanced oil recovery can take place in these oil reservoirs when prices are nearer $100 a barrel than $50 a barrel because higher oil prices justify more activity, Mohrbacher says. Even though infrastructure exists, it often has to be retrofitted, brought up to safety standards and special equipment brought to the site, he says.

"We typically recover between 30 percent and 50 percent of the oil in (Wyoming's) older fields using typical production techniques," he says. "Fifty to 70 percent of the original oil in place remains stranded and is still there to recover. We are trying to recover another part of that stranded oil."

Research options

The research lab is designed to help. The lab occupies approximately 2,500 square feet on the second floor of the EIC. Office space for EORI occupies 3,000 feet on the third floor. Both the lab and office space can be reconfigured to fit particular needs, Mohrbacher says.

- The lab provides researchers the ability to determine the types of rock and fluids that make up the reservoirs. Researchers can use the geographic information to create models of reservoirs.
- Researchers are able to create descriptions of reservoirs as well as generate state-of-the-art, three-dimensional visualization of the subsurface.
- Researchers can experiment with cores in oil and water in order to see how the cores behave and fluids flow through them.
- Taking information from the above experiments, researchers can develop simulations to determine how the various EOR technologies work.

The lab will help Wyoming maximize the benefit of oil wells already developed; move the nation toward energy independence; and create

jobs and benefits for the state by extending the life of the oil industry in the state by 20-30 years using enhanced oil recovery, Mohrbacher says. Wyoming ranked eighth in production of crude oil nationally as of 2010, according to the latest statistics available from the U.S. Energy Information Administration.

"This is the first time—since the early '70s—that the energy industry is talking about America being energy-independent with regard to oil production," he says.

Collaborative opportunities

EORI projects use an interdisciplinary approach. It is not uncommon for geologists, chemists, engineers and mathematicians to all work in concert on the same project, Mohrbacher says. The new facility will provide an excellent opportunity for student experience, enriching their research and supporting UW's prime mission: enhancing the workforce.

The EORI has created a culture that uses university resources, but does so in a manner that generates results that Wyoming oil operators appreciate, says Mohrbacher, who describes the institute as "a hybrid organization that embodies strengths of both academia and industry."

For example, the EORI developed the first static and dynamic models of the Grieve Oil Field in the Wind River Basin for Elk Petroleum. Elk Petroleum then formed a partnership with Denbury Resources. They're working on a carbon dioxide EOR flood to produce up to an additional 18 million barrels of oil that was previously stranded, Mohrbacher says.

Norm Morrow, a UW professor of chemical and petroleum engineering for 20 years, continues to conduct a strong, collaborative research program, including work with EORI engineers and UW faculty.

The new lab may become vital to continuing the experimental side of his research, says Morrow, who holds the Wold Chair of Energy and is a J.E. Warren Distinguished Professor, both at UW. This research includes various oil recovery processes, especially for tests that need equipment that enables closer simulation of reservoir conditions. A key factor in investigation of oil recovery from specific reservoirs is the supply, from oil companies, of high-quality reservoir crude oil and rock samples, Morrow says.

In concert with the Department of Mathematics at Australian National University, he recently published research on the mechanisms of oil recovery from the Tensleep, an aeolian sandstone formation. He also has published on the related Minnelusa.

These two formations account for about one-third of Wyoming's total oil production, he says. At least 50 percent of original, in-place oil still remains in these formations. Much larger untapped reserves are held in associated, natural residual oil zones.

About 55 percent of the world's oil is located in carbonate reservoirs, while 45 percent of it is in sandstone reservoirs, according to Morrow, who has a growing interest in carbonate formations.

"Most of the research has been done on sandstone. Carbonates are often fractured and what we call 'oil wet,' which means they don't suck water from the fracture and displace oil out. We're looking for ways to make that happen by promoting spontaneous imbibition."

Recovery by spontaneous imbibition is essentially the displacement of one fluid by another immiscible fluid, driven by the surface energy forces acting in the reservoir. An immiscible fluid is one that is incapable of being mixed with another to form a homogenous substance. For example, oil and water are immiscible.

Morrow has written papers on the subject relative to the Cottonwood Creek Field, which is a carbonate reservoir located west of Worland in the Big Horn Basin. Only about 10 percent of in-place oil in this reservoir has been removed because it's a fractured, oil-wet carbonate, he says.

"That would be a good project for Wyoming and the EORI lab" to tackle, Morrow says.

Testing of low-salinity water flooding, a process that increases oil recovery, also could be conducted in the Enhanced Oil Recovery Research Laboratory, Morrow says. The process has been shown to work well for reservoir rocks, both in laboratory testing and field pilot tests, he says. Low-salinity flooding, pioneered at UW, is categorized as a low-cost recovery method that is now being deployed field-wide by the industry, Morrow says. The process, for reasons not yet understood, is less reliable for outcrop sandstones.

"That's one of the many problems we're still trying to unravel in our laboratories at UW," he says.

Mohrbacher says the new lab allows the EORI to continue to conduct its work and research—and do more of it.

"EORI's capabilities and resources allow us to use the latest technology to evaluate and develop Wyoming oil fields," Mohrbacher says. "Only one or two other universities in the U.S. have similar capabilities."

Provided by University of Wyoming