Small Alaska agency has say on producing North Slope gas

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Among the huge decisions that will determine if a major North Slope gas project gets built is one that will fall on an obscure state of Alaska agency.

Without this agency's blessing, other milestone decisions may be moot, such as North Slope oil producers on constructing the liquefied natural gas project they're studying, or global lenders on fronting multibillions of dollars for construction, or Asian utilities on committing to buy North Slope gas for decades.

The small state agency that will deliver its own pivotal verdict is the Alaska Oil and Gas Conservation Commission. AOGCC will decide whether it's in the state's best interest to let a huge volume of natural gas leave the North Slope for market. The alternative for the gas that rises up oil wells at the Prudhoe Bay field is to continue injecting it deep underground to push more oil to the surface.

Given that the Alaska public for decades has pined for a North Slope gas project, the AOGCC decision might seem like a no-brainer: Let the gas go.

Except for one complicating factor: Gas injection is a strategy practiced at Prudhoe Bay for 35 years with spectacular success. Injecting gas has pushed billions of additional barrels of crude oil from the reservoir — the equivalent of finding several more elephant oil fields on the Slope.

This extra oil has extended the output of Prudhoe Bay far beyond original projections and helped make Alaska one of the nation's richest states — not to mention burnishing oil producer bottom lines.

Actually, the commission already has weighed in on how much gas can leave the North Slope. But it set that ceiling in 1977, before Prudhoe Bay even started producing oil, before anyone really knew for sure how the oil field would perform and how realistic the ceiling was.

No one ever has asked for a new look at the 1977 ceiling because a major gas sale never has been imminent.

But before major LNG production can start, the three AOGCC commissioners will need to revisit the ceiling their predecessors set two generations ago. That's because the big Prudhoe Bay producers say they'll likely need up to 50 percent more gas for their LNG project than the ceiling allows.

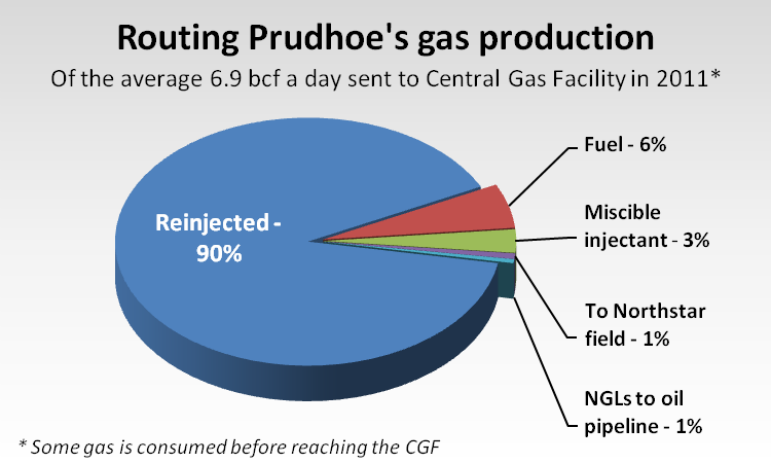
The commissioners will ponder the relative value of oil versus gas and how many barrels of oil will remain buried in Prudhoe forever when gas production starts. They will mull ways to shore up Prudhoe's underground pressure when less gas is injected. They will crunch the tricky calculus of engineering an aging oil-and-gas field.

And they might even have a couple of wild cards to consider. Can the aging infrastructure of Prudhoe Bay last long enough to get the field's gas out of the ground and piped to market? And on a less scientific and engineering issue, do the oil and gas commissioners want to be the people standing between Alaskans and their gas pipeline project?

THE 1977 ORDER

The commission has been around, in one form or another, since Alaska began producing oil and gas more than 50 years ago. Every state with petroleum production has a similar agency that regulates the fields to prevent waste of natural resources.

The Alaska commission is a small, quasi-judicial body charged with making sure the state gets the maximum wealth possible from its oil and gas resources. Three commissioners appointed by the governor lead it — at present they are a lawyer, a geologist and a petroleum engineer.



Source: BP

Considering the millions or even billions of dollars at stake in its decisions, the commissioners and their professional staff are housed in decidedly humble quarters: A one-story building in downtown Anchorage, tucked behind a department store.

Back in 1977, the commission weighed in on how much oil and gas could leave Prudhoe Bay. On June 1 of that year, in Conservation Order 145, the commission decreed that oil companies could produce 1.5 million barrels a day of oil and condensate plus 2.7 billion cubic feet a day of natural gas.

This order came on the brink of Alaska's birth as a major oil producer.

One day earlier, the new 800-mile trans-Alaska oil pipeline got its final weld. Twenty days after the order, producers pumped the first oil production into that pipeline.

As the oil started flowing in June 1977, plans were hatching for a large gas pipeline project, too. The thinking was that gas production would begin five years after oil production — it would take that long to build the gas system.

The commission said the 2.7 bcf per day of gas production would work out this way:

- About 2.2 bcf to 2.3 bcf would be dedicated to the gas pipeline. After cleansing that gas of carbon dioxide and other contaminants, about 2 bcf per day could be piped from the Slope.
- A few hundred million cubic feet would be burned as fuel at the Prudhoe oil field.
- A small amount would become valuable natural gas liquids after processing.

That breakdown worked for the gas pipeline proposed in the late 1970s. But the one under consideration today by the main Prudhoe producers — ExxonMobil, ConocoPhillips and BP — would be at least 50 percent larger, carrying 3 billion to 3.5 billion cubic feet per day.

PLAN A: INJECT WATER TO BOOST PRESSURE

In an oil field, pressure moves crude to and up the wells.

The standard technique for producing an oil field like Prudhoe Bay that also contains natural gas is to keep gas in the reservoir as long as possible to provide underground pressure needed to maximize oil production.

Producing gas causes a loss of pressure — and a loss of valuable oil production.

Only at the end of oil production does the gas get produced and sent to market — a process called a field "blow down." This approach provides the maximum oil *and* the maximum gas production.

If natural gas isn't available to maintain pressure, some substitutes might do, such as nitrogen extracted from the air or water.

Back in 1977, everyone talked about water injections as the answer to maintaining Prudhoe's reservoir pressure after gas production would start in the early 1980s. Water that rises up the wells with oil and gas would be the first pick for injection. But also water from elsewhere if necessary.

In May 1977, the Federal Power Commission weighed in on Prudhoe Bay gas offtake in its recommendation to President Carter on which Alaska gas pipeline project to favor. The commission had conducted more than two years of hearings on a Prudhoe Bay gas project.

"In order to attain a gas sales rate in excess of 2.0 Bcf/d (billion cubic feet a day) — or perhaps even to sustain a 2.0 Bcf/d sales rate over a prolonged period of time without adversely affecting the reservoir — a source water injection program and/or other reservoir management techniques will be required," the commission said. "By employing proper reservoir management techniques, this level of sales can be achieved without having a detrimental effect on a portion of in-place hydrocarbons ultimately recovered."

A month later, the Alaska oil and gas commission said in Conservation Order 145: "Reservoir studies have shown that both produced water injection and source water injection into the Prudhoe Oil Pool should increase oil recovery. Reservoir studies have shown that large scale source water injection will probably be necessary to maximize oil recovery."

The Alaska commission then added a cautionary note: All of these strategies — about how to produce Prudhoe's oil, about the volume of gas available for a gas pipeline, about injecting water to maintain pressure — could be revisited after oil production begins and everybody sees how Prudhoe actually behaves.

"These offtake rates may be changed as production data and additional reservoir data are obtained and analyzed," the order says.

That last sentence means the commissioners can raise or lower the 2.7 bcf a day ceiling depending on what's best for maximizing Prudhoe's production. Even the smaller 500 million-cubic-feet-a-day gas pipeline the state has proposed as a backup to a larger gas pipeline could need AOGCC permission to take gas from Prudhoe.

PLAN B: CAPTURE THE GAS LIQUIDS

The gas pipeline project envisioned in the late 1970s was never built. North American gas prices were too low to justify the multibillion-dollar construction cost.

As oil production started in 1977, also up from the wells came a fantastic quantity of natural gas.

Prudhoe is one of the nation's great storehouses of natural gas. Every day Prudhoe and neighboring oil fields produce an average of about 8 billion cubic feet of gas. (Most of it comes from Prudhoe.) That's enough to supply all U.S. households east of the Mississippi River with all the gas they need every day of the year.

Over time, the Prudhoe producers evolved their thinking about what to do with the oil field's gas bounty.

First, with no gas diverted into a pipeline, injecting gas, not water, would be central to keeping the Prudhoe reservoir pressurized. (Produced water does get injected, too.)

By the mid 1980s, the producers also had zeroed in on the money-making potential of a minority slice of the natural gas stream.

Prudhoe Bay gas	
Typical composition of produced Prudhoe gas	
Methane	80%
Carbon dioxide	12%
Ethane	5%
Propane	2%
Butane	0.2%
Pentane	0.04%
Hexane & heavier	0.02%
Nitrogen	0.6%

Source: State of Alaska

Natural gas at the wellhead typically consists of more than just methane, the gas that flows in pipelines and is burned in power plants and household furnaces.

Small amounts of heavier ethane, propane, butane and pentane are mixed in and have a higher market value than methane. By processing the wellhead gas and controlling for temperature and pressure, these other hydrocarbons will liquefy and drop out of the methane.

The producers now aimed to separate out these liquids, which comprise about 7 percent of the gas stream. (Methane is about 80 percent and carbon dioxide about 12 percent.)

Marrying chemistry know-how and engineering muscle, they built the biggest, most ambitious gas processing plant in the world to extract the liquids.

TURNING GAS LIQUIDS INTO MONEY

The Central Gas Facility opened at Prudhoe in 1986. The new strategy was so successful that the producers expanded this plant in 1990, 1993 and 1994 so it could handle more gas, according to BP, which runs Prudhoe Bay on behalf of itself and the other producers.

The plant is a giant — a quarter-mile long on one side. The 10-story compressor module weighs 5,400 tons.

Photo courtesy of BP
Prudhoe Bay Central Gas Facility

The plant can produce up to 100,000 barrels of natural gas liquids daily, although in recent years production has been about half of that, according to AOGCC figures. Since its inception it has processed more than 600 million barrels of gas liquids.

The producers put these liquids to use in three ways:

- Some gas liquids flow with crude oil through the trans-Alaska pipeline to market.
- Some get blended into a special cocktail called "miscible injectant" used to coax more oil from Prudhoe and a handful of neighboring reservoirs.
- Some get routed to the nearby Kuparuk River field for use in miscible injectant there.

The remaining gas — actually the bulk of the produced gas — gets pumped back underground to bolster Prudhoe's pressure.

Here's a brief look at these uses of natural gas liquids.

Gas liquids in the oil pipeline

Oil and natural gas are called hydrocarbons because they're comprised of hydrogen and carbon atoms. The more carbon atoms, the heavier the hydrocarbon and the more heat a given unit can produce. In general, more heat means more value.

Methane has one carbon atom, ethane two, propane three, butane four, etc. With enough carbon atoms you get crude oil. Another feature of these different hydrocarbons: The more carbon atoms, the higher the ambient temperature that will keep them in liquid form rather than as vapors.

The heaviest natural gas liquids — butane, pentane and hexane — will remain liquid at the same temperatures as crude oil in the trans-Alaska oil pipeline. So they can be, and are, sent to market at the same time in the same pipe.

Last year, the producers extracted an average of 50,000 barrels a day of natural gas liquids from the gas stream, according to AOGCC figures. Of that total, about 30,000 barrels a day of the heavier gas liquids flowed down the oil pipeline, according to BP. That was roughly 5 percent of what the oil pipeline carried.

Miscible injectant

Some carbon dioxide, methane, ethane and propane get blended into miscible (mixable) injectant used at a variety of North Slope fields to boost oil production.

At Prudhoe, BP pumps the miscible solvent under high pressure into the oil column's periphery.

The injectant mixes with oil stubbornly clinging to rock, relaxing the oil's grip. BP then pumps in water to flush the oil toward wells.

When the MI plant was last expanded, in 1999, the industry estimated the injections would wrest an extra 50 million barrels of oil from Prudhoe over time.

Miscible use at other fields

Some gas liquids get shipped to the Kuparuk River field west of Prudhoe.

ConocoPhillips, which runs the big oil field there, makes miscible injectant from a blend of Prudhoe liquids, Kuparuk liquids and other Kuparuk gas production.

Some smaller fields near Prudhoe also use miscible injectant, including the Orion, Polaris, Borealis, Aurora and Point McIntyre fields, BP said. (These fields are produced through the Prudhoe Bay facilities.)

Further, BP transports some Prudhoe gas to its Northstar field north of Prudhoe for use as fuel and injection gas that is miscible, the company said.

THE VIRTUES OF INJECTING GAS

In the absence of a gas pipeline, the shift to, and expansion of, natural gas liquids production at the Central Gas Facility has occurred with the blessing of the Alaska oil and gas commission.

In 1987, about a year after the Central Gas Facility started work, C.V. "Chat" Chatterton, then the commission chairman, extolled the wisdom of keeping Prudhoe gas at Prudhoe.

Already it was clear that more oil was being produced than expected thanks to gas injections, Chatterton said at a state-federal workshop on "Alaska Gas Utilization."

"The gas is now serving a useful purpose by staying at home and prolonging the time that the pool's crude oil allowable production rate can be maintained. Certainly, the state of Alaska's general fund is thankful. ... And I suspect that the owners of the gas, the Prudhoe Bay Unit participants, are equally thankful that oil production has yet to decline," Chatterton said.

"Just maybe, events to date provide a clue as to the use for ANS (Alaska North Slope) gas that will realize its greatest value. And that use is enhancement of crude oil production from oil fields north of the Brooks Range," he continued.

As for the new miscible injectant program, Chatterton said, "The economics ... are highly favorable and considered to be the lowest cost option for the North Slope gas utilization."

INDUSTRIAL-STRENGTH INJECTIONS

Gas liquids aside, the main show for Prudhoe Bay natural gas, as Chatterton noted, involves injecting it back into the field under ferocious pressure.

Since 1977 more than 63 trillion cubic feet of gas has been produced. About 56 tcf of that has been reinjected.

It's as if every molecule of gas originally in place at Prudhoe has been produced and injected twice in the past 35 years.

Besides the injected gas, about 6 tcf has been used up since 1977, mostly to fuel the oil fields, but also by the oil pipeline and two small utilities in the neighboring town of Deadhorse, according to state statistics.

Last year, Prudhoe's Central Gas Facility processed an average of 6.9 bcf a day. Of that, about 700 million cubic feet was used to make miscible injectant, burned as fuel, exported to the Northstar field or sent down the oil pipeline as liquids, BP said. (Other fields handle their own gas production. The entire North Slope produced about 8 bcf a day of gas last year.)

Photo courtesy of BP
Prudhoe Bay Central Compression Plant

That left about 6.2 bcf a day for injection at Prudhoe. BP pipes this gas next door to the Central Compression Plant, a beast of an industrial plant itself. That plant does just what its name implies: It super-compresses the gas molecules into tight formation — roughly 4,000 pounds of pressure per square inch — and punches them down into the gas cap that overlies the Prudhoe oil column and pressurizes it.

Because less gas is injected than is produced, Prudhoe has lost some of its underground pressure over time.

When production started in 1977, the underground pressure was 4,335 pounds per square inch. The pressure today has stabilized at about 3,300 psi, BP said.

The longer that produced natural gas stays at Prudhoe rather than getting sent down a pipeline for an LNG project, the more oil that will be produced.

In 1997, two state Revenue Department officials examined how much Prudhoe oil would be lost when major gas sales begin. For purposes of their study, they assumed a 1.9 bcf-a-day gas pipeline project would be completed in 2005 and would ramp up to full capacity by 2010.

They concluded a loss of 259 million barrels of oil production would result through 2029.

The authors, Roger Marks and Greg Bidwell, noted that the oil loss would be lower if the gas pipeline started up later or the ramp up was slower.

In 2007, still with no gas pipeline, a National Energy Technology Laboratory report forecast a smaller loss of oil due to a gas pipeline carrying 3.44 bcf a day starting in 2015.

The study predicted 133 million barrels lost from Prudhoe over time. But that loss would be offset by 400 million barrels of new oil and condensate production from the Point Thomson field east of Prudhoe, a field that would be developed to tap its gas for a gas pipeline, the authors said.

'NO TRIVIAL TASK'

The three Alaska oil and gas commissioners are well aware they could be asked to allow a significant amount of gas to leave Prudhoe Bay via a gas pipeline project.

To get ahead of the game, in 2005 they held public hearings on the old 2.7 bcf-a-day offtake ceiling. At the time, the Prudhoe producers were talking about a pipeline that could carry 4.3 bcf a day, expandable to 5.6 bcf.

Those hearings led the commission to study how much oil would be lost under different gas-offtake scenarios. The producers cooperated with the study, which was completed in 2007 and has been kept confidential.

"The Gas Offtake Study found insufficient information on which to justify increasing the offtake rate above 2.7 bscfd, but concluded that an early, high rate gas sale could result in the loss of a substantial volume of hydrocarbons, but even greater volumes could be lost if gas sales are too delayed," the commission said in a summary at the time.

The commissioners found it premature for the producers to provide a detailed "depletion plan," in advance of major gas sales, "that insures a greater ultimate recovery and prevents waste of oil and gas." But the producers need to demonstrate to the commission "that they are implementing near-term strategies to maximize oil recovery prior to gas sales."

Although the commission's 2007 offtake study is confidential, the agency that year published a series of short papers that outlined the situation.

The papers noted that generally the longer a gas-pipeline project is delayed, the less oil production that would be lost.

But Prudhoe Bay is an old oil field in a harsh climate with high maintenance costs. "The longer that gas sale is delayed, the greater the risk of well and facilities failure resulting in premature field shutdown," an AOGCC reservoir engineer wrote in a memo to the commissioners.

Another paper elaborates on aging Prudhoe Bay equipment. "The later in time that the gas is produced, the higher the costs will be to operate, repair and replace equipment and, thus, the sooner the gas will become uneconomical to produce and the more gas that will be left stranded."

In meeting their responsibilities, the paper continues, the commissioners "must be cognizant of the balance between oil recovery optimization and gas recovery optimization.

"This will be no trivial task."