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Department of Revenue
Commissioner's Office

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Representative Paul Seaton
State Capitol Room 102
Juneau AK, 99801

Re: Economic Analysis of Alaska North Slope Gas to Liquids Plant

Dear Rep. Seaton:

This letter is in response to the questions raised in Louie Flora's November 16, 2010 email relating to Gas to Liquids (GTL) technology and the viability of a Gas to Liquids plant in Alaska. In the November email, the department was requested to produce modeling where the GTL plant is downstream of the point of production and on a 20 year amortization schedule similar to a pipeline tariff repayment; the plant is built in three module increments producing 35,000 bpd each, and operates at an efficiency of 70%. The Department of Revenue analyzed whether a GTL plant is economically feasible and what impacts such a plant would have on state revenue. The results are summarized in this letter. We have also provided additional information on the GTL process and products and the current projects around the world as an attachment to this letter.

<u>Modeling Assumptions</u>
Numerous assumptions are required to analyze the economics and revenue impact of a GTL plant in Alaska. To generate these assumptions, we relied upon earlier work done by the Department of Revenue, several studies by the U.S. Department of Energy, information provided by GTL experts at Gaffney Cline, and public information available on existing GTL plants. All costs and price estimates are in real 2011 dollars.

Key Assumptions

GTL Plant Specifications

- The GTL plant is located on North Slope and producer owned;
- The plant consists of three modules (or trains) which produce 35,000bbls/day of syncrude over a 20 year life;

- The plant operates at 70% efficiency, and at peak production it converts about 0.8bcf/day of natural gas into 105,000bbls/day of GTL products. Over the life of the GTL plant, a total of about 5.8 trillion cubic feet of natural gas is used to produce approximately 770mmbbls of syncrude. According to a recent DOE report, Prudhoe Bay alone is estimated to contain 23.7tcf of exportable hydrocarbon natural gas reserves (produced gas less CO2, lease use, local sales, and shrinkage).[1]

GTL Plant Capital and Operating Costs

- Base, low and high-case capital costs are $12.60 billion ($120,000 per daily barrels), $7.35 billion ($70,000 per daily barrels), and $17.85 billion ($170,000 per daily barrels);
- GTL Plant operating expenses of $10 per bbl of GTL product produced (e.g. 38mmbls/year x $10/bbl = $380 million per year to operate).
- Since the GTL plant is producer owned, the price of natural gas entering the GTL plant is not a cost incorporated into the project's cash flow.

GTL Product Value

- The GTL product is assumed to carry a 30% premium to the West Coast price of Alaska North Slope (ANS) crude oil;
- We present a range of ANS WC crude oil prices from $50 - $150/bbl in Tables 1 and 2 below;
- GTL products are batched down TAPS, and additional TAPS throughput reduces the TAPS tariff.

Tax and Royalty Assumptions

- The plant is downstream of point of production for production tax purposes, and the plant's capital costs and operating expenses are not deductible costs in calculating production taxes.
- The royalty is based on the value of the natural gas and not the GTL product.

It is important to note that this model analyzes the economics and revenue impact of a GTL plant and not the feasibility of a GTL plant project vis-à-vis a natural gas pipeline. An important part of the decision to undertake this project is whether it is more profitable to monetize natural gas reserves with a GTL plant rather than a natural gas pipeline. Our analysis does not address this question, but rather it focuses on the more narrow issue of whether a GTL plant is economically viable and what impact such a plant would have on state revenue.

Modeling Results

To assess the underlying economics of this project, we calculate the project's internal rate of return (IRR). The IRR is the discount rate that makes the net present value of the project's cash flow equal to zero. While this is only one of many metrics, the IRR is widely used and allows

[1] http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/ANSSummaryReportFinalAugust2007.pdf

this project to be compared to alternative projects with different time horizons and capital outlays.

The primary drivers of the GTL plant's economics are the value of the GTL products and the plant's capital costs. Table 1 below shows the IRR of the project for a range of ANS WC prices and three capital cost scenarios. The GTL products are assumed to have a 30% premium over the price of ANS WC crude oil.

Table 1 below shows under the right combination of oil prices and capital costs, the GTL plant has strong internal rates of return. For base-case capital costs, an ANS WC price of close to $70/bbl is required for the project to have a 10% IRR, and a $120/bbl price is required for a 15% IRR. It is important to note that for a project to be viable, the IRR must exceed a hurdle rate that covers both the costs of financing the project and any risk premium.

Table 1

GTL Project Internal Rate of Return

ANS WC Price	Low Costs $70,000 per daily barrels	Mid Costs $120,000 per daily barrels	High Costs $170,000 per daily barrels
$50	11%	7%	4%
$60	13%	9%	7%
$70	15%	11%	8%
$80	16%	12%	10%
$90	17%	13%	10%
$100	18%	13%	11%
$110	19%	14%	12%
$120	20%	15%	12%
$130	21%	16%	13%
$140	22%	16%	13%
$150	22%	17%	14%

The impact on state revenue also varies substantially depending on the value of the GTL products and the plant's capital costs. Table 2 below shows the net present value of the project's state revenue impact for a range of ANS WC prices and three capital cost scenarios. The discount rate for the state is assumed to be 5%.

Table 2

NPV of State Revenue ($Billions)

ANS WC Price	Low Costs $70,000 per daily barrels	Mid Costs $120,000 per daily barrels	High Costs $170,000 per daily barrels
$50	2.950	2.024	1.382
$60	4.513	3.011	1.692
$70	6.084	4.284	2.592
$80	7.638	5.739	3.825
$90	9.356	7.522	5.604
$100	11.149	9.330	7.561
$110	13.046	11.098	9.202
$120	15.061	12.985	10.960
$130	17.195	14.990	12.837
$140	19.448	17.115	14.833
$150	21.820	19.359	16.948

Table 2 above shows the net present value of state revenue generated by the project can be over $10 billion with certain combinations of oil prices and capital costs. In the base-case scenario, a price of over $105 yields a net present value to the state of more than $10 billion.

The increase in revenue is primarily due to an increase in production taxes, which rises because of the additional 105,000bbls/day of production, the high premium GTL products carry over the West Coast price of ANS crude, and the lower TAPS tariff resulting from increased TAPS throughput. The property tax impact of a GTL plant and the royalty assessed on the natural gas entering the plant are also included in our analysis.

There are many issues not incorporated into our analysis that merit comment. First, building a GTL plant would require years of permitting, engineering, and commitment by the companies that hold leases with natural gas reserves. Second, there are unresolved technical issues with shipping GTL products through TAPS. Third, while newly discovered natural gas reserves can be shipped in a natural gas pipeline by expanding the pipeline’s capacity, adding capacity to a GTL plant may require an additional GTL plant module. Constructing a GTL module is expensive, and this may inhibit the development of natural gas reserves if the gas reserves are not large enough to justify construction of an additional module.

Conclusions

Our modeling shows that in certain scenarios a GTL plant may be economically viable and bring in substantial revenue to the state. The key drivers of the project’s economics and impact on state revenue are the price of crude oil and the plant’s capital costs. Crude oil prices are notoriously volatile and difficult to forecast, and capital costs estimates for a project of such magnitude should be taken with caution. Hence, there is a great deal of uncertainty involved in undertaking this project.

We hope this analysis fulfills your request and provides an opportunity for further discussion on the economic viability and state revenue effects of a GTL plant. We look forward to answering any follow-up questions you may have regarding our work.

Sincerely,

Bruce Tangeman
Deputy Commissioner

Cc: Louie Flora
Bryan Butcher, Commissioner
Jonathan Iversen, Tax Director

Enclosed: Additional Information on GTL

Additional Information on Gas-To-Liquids

Background

Gas-to-Liquids refers to the process of converting natural gas (methane) to high valued liquid petroleum products, mainly diesel fuel and naphtha. The process is very expensive and capital intensive. However, GTL technologies may be feasible at current and forecasted oil prices and could play a part in commercializing North Slope natural gas reserves. A potential GTL project on the North Slope would convert natural gas to GTL products, batch them into the crude oil, and ship them through the Trans-Alaska Pipeline (TAPS) to Valdez.

Process

Although there are various competing GTL technologies, they all use similar processes. There are three basic steps. First, oxygen, methane, and steam are combined at high temperatures to produce synthesis gas (syngas), a mixture of carbon monoxide and hydrogen. To make syngas, some of the technologies require pure oxygen and some start with air. The former processes incur a high capital cost to isolate the oxygen. The latter process necessitates the costly use of larger reactor vessels to accommodate the atmospheric nitrogen (nitrogen comprises about 80 percent of the earth's atmosphere).

The second step involves the Fischer-Tropsch (F-T) process, a chemical reaction between carbon monoxide and hydrogen in the presence of a catalyst such as cobalt or iron, under certain temperatures and pressures, which converts the syngas to liquid hydrocarbons and water. This process was discovered in Germany in 1923 and used by the Germans to convert coal to liquid fuel during World War II. The process produces a long chain paraffinic (waxy) hydrocarbon.

The last step is to upgrade the product to high-quality GTL products.

Product Values

GTL products are very clean. They are virtually free of sulfur, nitrogen, nickel, vanadium, asphaltenes, aromatics and salt. GTL diesel has a high cetane rating, which facilitates fuel ignition and cold-weather performance. GTL product are almost exclusively hydrogen-saturated paraffinic hydrocarbons, and the consequent relatively high hydrogen content leads to lower flame temperatures inside the engine, which in turn reduces nitrous oxide emissions. GTL diesel would meet the specifications for California Air Resources Board (CARB) diesel. Based on the historic relationship between ANS and CARB diesel, we estimate GTL diesel would carry a 35% premium over ANS.

GTL naphtha is almost purely paraffinic with low concentrations of naphthenes and aromatics. While, unlike most naphtha, this would preclude its use for gasoline feedstock, it makes an excellent feedstock for steam cracking operations to produce petrochemicals, especially ethylene. As ethylene feedstocks are in surplus on the West Coast, the most lucrative petrochemical market in the Pacific Rim for petrochemicals is China. Based on the historic relationship of ANS to naphtha prices in China, we estimate GTL naphtha would carry a 20% premium over ANS.

Converting natural gas into useful ultra-clean liquid fuels is an attractive prospect, particularly where the gas resource is effectively "stranded" in a remote location, making the conventional routes to market – by long distance pipelines or conversion to liquefied natural gas (LNG) for shipment by sea uneconomic.

Advances in GTL Technology

In 2002, BP[2] brought on its Nikiski GTL plant which produced 300 barrels per day and included a compact reformer, fixed bed FT reactor and hydrotreater. It operated through several Alaskan winters. BP has established that the process is very reliable, operable and controllable. They have learned much about catalyst life, activation and loading and unloading procedures – after three years the catalyst in the FT stage came out of the reactor like new. The Nikiski program required an investment of over $500 million. BP has shown itself to be capable of successfully constructing and running a GTL plant in remote Alaska, with temperatures down to -20 C in regions subject to earthquakes and volcanic eruptions.

BP plans a new 'next generation' fixed bed FT pilot plant to be built at BP's Hull Research and Technology Centre (HRTC) in the UK. The plant will test catalyst formulations and optimize process steps to develop a more advanced fixed bed process. Another type of FT process has been under trial at HRTC in the form of an advanced slurry process. The FT slurry reactor is different than the fixed bed process. In the fixed bed, the catalyst which promotes conversion of syngas to paraffins is packed inside tubes with the gas passing through them; the reaction is highly exothermic and the reactor must be designed to remove heat quickly. In the slurry reactor, the catalyst is dispersed in the liquid paraffin wax product within a large vessel with bubbles of syngas passing through it creating a three-phase slurry. The slurry of catalyst particles and paraffin wax product is constantly removed from the vessel by pumping around a loop where excess heat is removed in an external heat exchanger, the catalyst and product are separated and the catalyst returned to the reactor.

ExxonMobil's Gas to Liquids technology is the result of a research, development and engineering program spanning 20 years and costing $600 million.

Pearl GTL[3] will be the world's largest source of gas-to-liquids (GTL) products, producing 140,000 barrels of GTL products each day (the plant will also produce 120,000 barrels of oil equivalent per day of natural gas liquids and ethane). Startup of the plant is imminent. The plant is operated and funded by Shell at a development cost of $18-$19 Billion. Expected payout for the plant has been estimated at 3 to 4 years. Shell's Pearl GTL project, for example, can generate an annual profit of US$6bn based on an oil price of US$70 per barrel, according to remarks in March 2010 by the company's executive vice-president for Qatar, Andrew Brown. The plant uses 320 mboe/d of gas.

A South African firm[4], Sasol has announced it would spend just over $1 billion Canadian dollars to buy a half-interest in a Canadian shale gas field, so it can explore turning natural gas into diesel and other liquids. Sasol's proprietary conversion technology was developed decades ago to help the apartheid government of South Africa survive an international oil embargo and it is a

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[2] BP Global Website – Reports and publications – Syngas synergies, <http://www.bp.com/genericarticle.do?categoryId=9011237&contentId=7021393>

[3] Shell Website, Pearl GTL – <http://www.shell.com/home/content/aboutshell/our_strategy/major_projects_2/pearl/overview/>

[4] Matthew L. Wald, New Interest in Turning Gas to Diesel, 23 Dec. 2010, NYTimes.com, <http://www.nytimes.com/2010/12/24/business/energy-environment/24fuel.html?_r=1&src=busln>

refinement of the technology used by the Germans to make fuel for the Wehrmacht during World War II. “The acquisition of this high-quality natural gas asset will accelerate our upstream growth while also advancing Sasol’s already strong GTL value proposition,” said Sasol CEO Pat Davies.