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Bitumen Partial & Targeted Upgrading the Next Step

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ABSTRACT

Growth in light oil production in the U.S. and extra capability of many refineries to handle heavier feedstock has reduced the profits that could be realized from bitumen upgrading. Consequently, other options to full upgrading have to be considered in order to add value to Alberta bitumen and secure future markets.

Now is the time to consider partial or targeted bitumen upgrading to increase value for Alberta Bitumen. Partial upgrading does less processing than full upgrading or refining, and is therefore less costly. Small partial upgraders may be well suited to be located near in situ production facilities or may be suitable to locate larger capacity merchant partial upgraders in a central Alberta area.

This paper introduces an alternative concept for partial upgrading based on a combination of asphaltene extraction and gasification followed by Fischer-Tropsch synthesis. This concept is patented by Expander Energy Inc. of Calgary under the name FTCrude®.

KEYWORDS

Partial Bitumen Upgrading, Targeted Bitumen Upgrading, PUB, Bitumen Upgraders, FTCrude®, SynDiesel®.

INTRODUCTION

Alberta oil sands production is projected to reach 3.2 million bbl/d by 2020 and further increase by 2030 to about 5.2 million bbl/d. Clearly there is no existing capacity to upgrade this amount of bitumen into light synthetic oil to accommodate these forecasted production rates. To facilitate the processing of this new production, additional upgrader capacity of some form needs to be built or the bitumen must be transported and sold as DilBit, an example of which is Western Canadian Select (WCS). Upgraders can only be justified when the price spread between unprocessed bitumen and the synthetic crude is sufficient to recover the large capital investment required. Growing light oil production in the U.S. and capability of many refineries to handle heavier feedstock has reduced the economic returns that have

been previously realized from bitumen upgrading. Consequently, other processing options to full upgrading need to be considered to add value to Alberta bitumen.

Now is the time to consider partial or targeted bitumen upgrading. Partial upgrading requires less processing than full upgrading, costs less, and in addition may be well suited to be located adjacent to the upstream primarily in-situ facilities. Alternatively, it may be suitable to locate as larger merchant partial upgraders in central Alberta area, such as Edmonton.

There are several alternatives in partial upgrading concepts. Most of these technologies, based on some form of mild or reduced thermal cracking, offer reduced viscosity or less diluent requirement for the final product. The primary goal is to achieve pipelineable crude at minimum cost. All this is realized at the expense of volumetric losses through waste by-products and potential crude quality risk with additional risk due to high quantities of olefins present in the cracked partially upgraded bitumen.

This paper introduces an alternative concept for partial or targeted upgrading based on a combination of asphaltene extraction and gasification, followed by Fischer-Tropsch synthesis. This concept is patented by Expander Energy Inc. of Calgary, Alberta under the name FTCrude® Partial Upgrader.

Current Alberta Bitumen Markets

Current marketing strategies for Alberta Bitumen rely on the addition of diluent derived from natural gas liquids (NGLs) and upgrader produced naphtha streams (DilBit), or by adding Alberta produced SCO (SynBit) to reduce viscosity required for pipeline transportation. A typical combined blend is Western Canadian Select (WCS) blend which is about 20°API with a viscosity less than 350 cSt at 15°C. For short pipeline routes the diluent can be recovered and returned by separate diluent pipeline to the upstream producer. However, for long distance pipelines to transport bitumen to remote Canadian and USA refineries, or marine shipments to remote Asian markets, it may not be economically and environmentally feasible to recover and return the diluent as a second return pipeline and or marine transport will be required, adding significant costs.

Although this strategy is the "Low Capital Case" to move WCS to market, there exist a number of concerns for the future;

1. Long term and cost effective supply of diluent,
2. Feasibility of diluent recovery and recycle,
3. Impact of light diluent on USA refineries, already concerned about light ends in crude feed streams from shale oil,
4. Compatibility of heavy bitumen blend feeds with current Canadian and USA refineries,
5. Impact and disposition of environmentally undesirable byproducts such as heavy metals, sulfur and petcoke production,
6. Pipeline capacity and economic feasibility issues with high diluent content in DilBit,
7. Environmental concerns related to risk of transporting DilBit by rail, marine and pipeline.

Will New Bitumen Upgraders be built in Alberta?

Current Bitumen Upgraders produce Synthetic Crude Oil (SCO) which resembles light, sweet crude oil, with density typically greater than 30° API. Generally SCO sales receive a small premium to WTI of about 5 to 10%, or $5 to $10 per barrel.

Historically these Upgraders typically require a light-heavy oil (WTI to WCS) price differential of at least $25 per barrel to attract investment consideration. However, the 2008 recession and current surplus in the world crude oil market have caused a collapse in the light-heavy price differential, currently in the $12 to $15 range.

In addition, excess refining capacity is available in North America and for many refineries WCS may not be a compatible feedstock. Further, in past years, due to the unstable markets for Alberta DilBit, the industry has experienced large fluctuating price discounts for WCS in the range of 10% to 50% to WTI.

Rising Alberta based capital costs have also had major impact on development of new upgrading or refining projects. As an example, recent articles have reported that the capital cost for the latest Alberta Upgrader, the NorthWest Redwater refinery, 50,000 BPD diesel refinery has increased from early estimates of $5.5 billion ($110,000/BPD), to $8.5 billion ($170,000/BPD) ($Cdn).

Based on these factors, the chance of building a new grass roots Bitumen Upgrader in Alberta in the near future is very low. Consequently, other Upgrading options for adding value to Alberta bitumen needs to be considered, rather than through full upgrading or highly discounted Dilbit.

Is Partial or Targeted Upgrading the next step?

Since full bitumen upgrading is not currently feasible and the market strategy of DilBit has uncertainties, partial upgrading is proposed as the logical next step.

The basic partial upgrading process will target the production of a partially processed product, or Partial Upgraded Bitumen (PUB) designed to just meet the pipeline specifications for gravity and viscosity, about 20° API and viscosity less than 350 cSt at 15 °C.

The primary objective is to upgrade the bitumen to a pumpable PUB product without the addition of diluent or provide for significant reduction of diluent for each mode of transport; trucking, rail, marine and pipeline. It is further desired that the major impurities such as sulfur, nitrogen, Conradson Carbon Residue (CCR), heavy metals (Ni, Va) and acidity (TAN) be removed or reduced to create a desirable crude quality for all or most refineries.

And finally, the key objective is for partial upgrading to achieve the above results at a significant reduction of capital and operating cost when compared to full upgrading.

There are several technologies at various stages of development suitable for partial upgrading. Most of these technologies are based on thermal cracking of some fraction of the bitumen, and offer reduced viscosity or less diluent requirement for final product. All this is realized at the expense of volumetric losses of waste products such as asphaltenes or petcoke. The product yields are in the range 70-90 volume percent of the bitumen feed. It should be further noted that thermally cracked materials can be incompatible and unstable, and can form solids when mixed with other pipeline or refinery streams. The inherent presence of olefins caused by cracking may also be an issue.

Table 1.0 Current Partial Upgrading Technologies

PROCESS	CCU	HTL	Value Creation	ROSE	HI-Q	ftcrude
LICENSOR	UOP	Ivanhoe	Value Creation	KBR	MEG Energy	Expander Energy
PROCESS STEPS	SDA + RFCC	Pyrolysis + Coking	SDA + Coking	SDA	Thermo-cracking+SDA	SDA + Gasification + FT
BYPRODUCTS	Asphaltene + Coke	Coke	Asphaltene + Coke	Asphaltene	Asphaltene	NONE
EST SCO YIELD (vol%)	75-80	75-85	75-85	65 - 85	75-85	110 to 130

FTCrude® Partial and Targeted Upgrading Concept

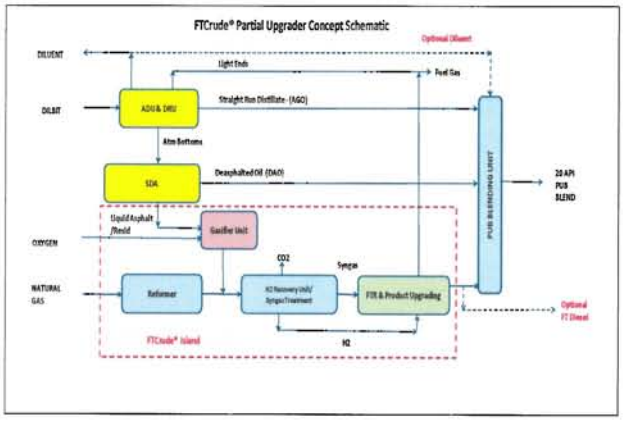
Expander's FTCrude® concept of partial upgrading applies a unique and patented method for improvement over the other technologies in that it utilizes the rejected by-products to generate incremental light distillate products. These products can be used not only as diluent but as PUB product enhancement as well.

FTCrude® is a patented concept developed by Expander Energy Inc. of Calgary, Alberta. In this concept, configured as a bitumen partial upgrader, atmospheric residue from a diluent recovery unit (DRU) is deasphalted, and the recovered asphaltenes are gasified to generate clean syngas, primarily consisting of H_2 and CO. Gasifier syngas is enhanced with hydrogen-rich Reformer syngas to provide a stoichiometric feed for Fischer-Tropsch (F-T) synthesis, which in turn produces a synthetic fuel product, principally consisting of high-cetane paraffinic diesel or SynDiesel®

.

Deasphalted oil (DAO), straight run distillate and the F-T product are then blended to form partially upgraded SCO with API gravity greater than 19° and viscosity less than 350 cSt at 15 °C. No additional diluent is required. The volumetric yield in this case is in excess of 110 percent of the bitumen feed; depending on the bitumen feed properties and asphaltene content. The FTCrude® partial upgrader concept is presented in Figure 1.0.

Figure 1.0 FTCrude® Partial Upgrader Schematic



In addition to production of pipelineable partially upgraded product, the FTCrude® Partial Upgrader concept is flexible and can be configured to produce a wide range of targeted blends. These blend compositions can be tailor made to strategically

supply specific refinery requirements and can be trucked, rail, or marine transported. Typically these alternate blends will have API gravity in the range of 14° to16° API and pumpable viscosity less than 5,000 cSt at 15°C or less than 350 cSt at 50°C.

FTCrude® Partial Upgrader Pilot Experimental Work

Expander Energy contracted in 2014 Saskatchewan Research Council (SRC) in Regina to confirm the validity of the FTCrude® Partial Upgrader concept of bitumen partial upgrading through lab scale pilot work supported by extensive lab analyses.

Diluted bitumen (14.7 °API) and F-T liquids samples were received as the starting feed streams and analyzed. SRC subsequently conducted atmospheric distillation to recover the diluent and produce straight run distillate and atmospheric residue. The atmospheric residue bottoms were then used for multiple deasphalting runs at various temperatures, solvent streams and solvent ratios. Pentane was used as the primary solvent.

Based on the laboratory deasphalting results (DAO and asphaltene quality and yields), Expander Energy used a proven syngas generation and F-T synthesis model to predict the corresponding yields of F-T liquids to be added to the DAO and SR distillate. These streams were then combined to constitute a partially upgraded bitumen (PUB) with API gravity higher than 19° API (SG = 0.94) and viscosity less than 350 cSt at 15°C.

In conjunction to the principal PUB blend described above, the following additional blends from the same bitumen feed were produced and fully analyzed for comparison to pipeline specifications.

- Dilbit (5.6 °API bitumen plus diluent)
- Deasphalted bitumen plus diluent (18 °API)

SRC also produced rail/marine type pumpable PUB blend:

- 14 to 16 °API blend consisting of PUB plus straight bitumen

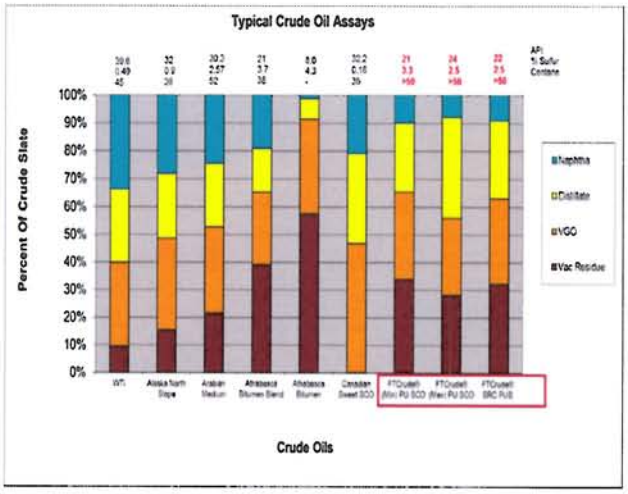
All referenced blends including their composition, distillation, chemical and physical properties are summarized in Table 2.0 below.

Table 2.0 Partial Upgraded Crude (PUB) Test Results

Blend Name	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Rail/Truck/ Marine Blend	Deasphalted Dilbit
Components (wt%)						
Deasphalted Oil			46.9	43.9	26.9	48.2
Straight Run Distillate			21.6	21.4	12.5	22.2
FT Sample A			31.5	34.6	18.1	
Diluent (additional)	17.5	18.0				29.7
Raw Bitumen	82.5				42.6	
Dilbit		82.0				
Total	100.0	100.0	100.0	100.0	100.0	100.0
Properties						
Viscosity cPat 10C	11,600	338	383	225	16,176	909
Viscisty CP at 30 C	1,740	102	122	68	2,475	257
Density kg/m3 at 10C	967.9	928	921.8	910	970.6	949.1
API Gravity	14.7	20.9	22	24	14.3	18
Sulphur	4.70%	3.57%	3.19%	2.92%	4.34%	3.44%
Asphaltenes (n5 solvent)	18.30%	16.60%	5.66%	4.74%	9.82%	2.94%
Microcarbon (w/w)	12.90%	11.42%	6.01%	6.23%	7.02%	5.57%
Nickel (mg/kg)	73	63	30	28	47	14
Vanadium (mg/kg)	190	170	78	75	126	35
Distillation (F)						
IBP	36	1	28	0	60	17
50%	557	443	420	398	484	439
80%	n.a	608	588	577	616	595
FBP	n.a	741	738	738	741	739

Blend assays with respect to naphtha, distillate, VGO and vacuum residue volume fractions for various common North American Crudes and the FTCrude® PUB blends are presented in Figure 2.0 below. The FTCrude® Min and Max results represent the simulated PUB blend assays calculated for minimum and maximum SDA asphaltene gasified volumes.

Figure 2.0 Typical Crude Oil Assays



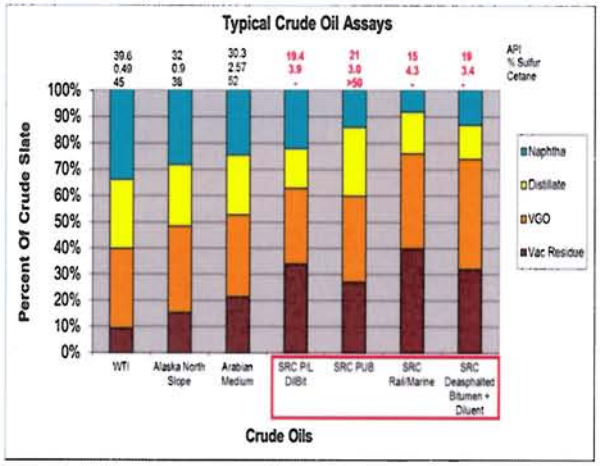
In conclusion, the SRC work confirmed the validity of the FTCrude® PUB concept for partial and targeted bitumen upgrading with actual numerical and analytical data even when using a very difficult bitumen (5.6 °API).

For the principal FTCrude® PUB configuration (i.e. combination of SR distillate, DAO and FT liquids), the process generates sufficient amount of FT liquids

to produce pipeline quality PUB. Depending on the level of deasphalting (solvent composition, solvent ratios and deasphalting temperatures), potentially FT liquids can be produced in excess to the PUB specification requirements. In this case, excess FT liquids can be sold as separate high value product such as SynDiesel®.

Similarly, the FTCrude® PUB concept is very flexible in producing various blends suitable for trucking, rail or marine transport. A typical 14 to 16 °API blend can be produced by either using less FT liquids in the PUB blend or by adding additional raw bitumen to the 20+ °API PUB blend, as shown in the following figure 3.0.

Figure 3.0 SRC PUB Crude Oil Assays



Partial Upgrader Basic Economic Indicators

The individual blend volumes based on 100,000 BPD raw bitumen feed are summarized in the following table:

Table 3.0 Volume Fractions of PUB Blends

Based on feed 100,000 bpd Bitumen	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 - Blend	Marine/Rail Blend	Deasphated Bitumen Dilbit
Blend Density (API)	14.7	20.9	22	24	14.3	18
Components (BPD)						
Deasphalted Oil			51,617	49,198	28,711	51,617
Straight Run Distillate			23,800	23,800	13,238	23,800
FT Sample A			45,964	50,816	25,566	
Diluent (additional)		36,653				37,303
Bitumen	100,000	100,000			44,377	
Diluent (as received)	29,200	29,200				
TOTAL PUB	129,200	165,853	121,381	123,814	111,892	112,720
Diluent	29,200	65,853	0	0	0	37,303
Vol % Diluent	22.6%	39.7%	0.00%	0.00%	0.00%	33.1%

Table 4.0 illustrates the feed input and product output streams for each of the PUB blends. Based on the pricing of individual components, the added value to each product can be calculated. This added value to the products can be used as a primary economic criterion for an economic justification of a partial upgrader. The added value is further evaluated against required capital to arrive at estimated project financial performance.

Table 4.0 FTCrude® PUB Upgrader Stream Balance

100,000 bpd Bitumen feed - FTCrude®Partial Upgrader	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Marine/Rail Blend	Deasphated Bitumen Dilbit
Feed (BPD)						
Bitumen	100,000	100,000	100,000	100,000	100,000	100,000
Diluent	29,200	65,853				37,303
Natural Gas (mmscfd)			220	250	122	220
Products (BPD)						
Dilbit (max 350 cSt @ 15 C)		165,853				
DA Bitumen/Diluent (20 API)						112,720
PUB (max 350 cSt @ 15 C)			121,381	123,814		
Marine/Rail Blend (14-16 API)	129,200				111,893	
Separate FT Product Syndiesel®						45,964
TOTAL PRODUCTS	129,200	165,853	121,381	123,814	111,893	158,684
Product Yield to Bitumen (%)	129%	166%	121%	124%	112%	121%

The basic economic evaluation was conducted using the following pricing scenarios for input and product streams:

Table 5.0 Current Commodity Pricing Scenarios

Current Commodity Prices ($US)			
WTI	$ 50.00	per BBL	
WCS Dilbit	$ 37.50	per BBL	25% Discount WTI
Bitumen	$ 20.00	per BBL	60% Discount WTI
Diluent	$ 45.00	per BBL	10% Discount WTI
FTCrude® PUB	$ 41.25	per BBL	10% Premium WCS
Deasphalted Dilbit	$ 39.38	per BBL	5% Premium WCS
Marine/Rail Blend	$ 35.63	per BBL	5% Discount WCS
Dilbit Received	$ 30.00	per BBL	20% Discount WCS
Syndiesel®	$ 0.60	per Litre	90% Premium WTI
Natural Gas	$ 3.00	$/MMBTU	

Based on the commodity pricing scenarios and input and output streams, the daily and annual revenue estimates were predicted and are presented in Table 6.0. An additional case was evaluated based on a PUB crude product consisting of deasphalted bitumen + reduced diluent for Canadian and USA refineries, and a separate FT SynDiesel® stream marketed to local Alberta markets.

Table 6.0 FTCrude® PUB Upgrading Commercial Value Comparison

100,000 bpd FTCrude® Bitumen partial upgrader - $/year revenue	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Marine/Rail Blend	Deasphalted Bitumen/Dilbit + FT SynDiesel®
Input Costs ($/day)						
Bitumen	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000
Diluent	$1,314,000	$2,963,385				$1,678,635
Natural Gas			$660,000	$750,000	$366,000	$660,000
Oxygen Cost @$50/MT			$110,000	$110,000	$74,250	$110,000
Fixed OPEX @ 4% CAPEX			$315,152	$315,152	$218,182	$315,152
Total Feed ($/day)	$3,314,000	$4,963,385	$3,085,152	$3,175,152	$2,658,432	$4,763,787
Products ($/day)						
Dilbit (max. 350 cSt @ 15 C)		$6,219,488				
DA Bitumen/Diluent (20 API)						$4,438,350
PUB (max. 350 cSt @ 15 C)			$5,006,966	$5,107,328		
Ship/Rail Blend (14-16 API)	$4,602,750				$3,986,188	
FT Syndiesel® Sales						$4,389,351
Total Products ($/day)	$4,602,750	$6,219,488	$5,006,966	$5,107,328	$3,986,188	$8,827,701
Added value ($/day)	$1,288,750	$1,256,103	$1,921,815	$1,932,176	$1,327,756	$4,063,914
$ MM @ 330 days	$425	$415	$634	$638	$438	$1,341
Transport Tariff ($5.00/BBL)						
Est Shipping Cost ($/day)	$646,000	$829,265	$606,905	$619,070	$559,465	$563,600
Est Annual Shipping Cost ($M/yr)	$213	$274	$200	$204	$185	$186
Est Capex ($MM US)			$2,600	$2,600	$1,800	$2,600
Project Unlevered IRR (%)			20.0%	20.1%	20.0%	36.6%
Return NPV@15%	$1,586	$1,065	$871	$892	$600	$4,381

The above results are only presented for general illustration purposes to demonstrate the benefits of the FTCrude® PUB Upgrader concept. Each project must be evaluated in detail with accurate engineering evaluation and specific capital cost analysis.

Conclusions and Observations

- There is no economic climate for Full Bitumen Upgraders to produce SCO at the current light-heavy differential of less than $15/bbl.
- Utilizing the FTCrude® PUB concept, partially upgraded bitumen can be pipelined without the addition of diluent. This provides a major economic advantage when long diluent return pipelines would otherwise be needed.
- Compared to regular Dilbit, the FTCrude® partially upgraded bitumen is significantly higher in distillate content and lower in sulfur, heavy metals, TAN and CCR.
- FTCrude® PUB has a specific gravity less than 1.0, in range of 0.92 to 0.94, therefore will be lighter than water.
- FTCrude® PUB configuration provides high carbon retention and efficiency, thus resulting in lower CO_2 emissions without the production of undesirable waste by-products such as petcoke, asphaltenes or high sulfur fuel oil.
- Partial or targeted upgrading offers significant returns on investment even at current depressed crude oil prices (less than $50/bbl) since the actual diluent with FTCrude® PUB will, in effect, be low cost natural gas (less than $3/mmbtu).
- Partial upgraders could be built as multiple satellite facilities with capacities of 10,000 to 50,000 BPD, or as larger centralized plants with individual capacities of 100,000 BPD or more. The primary partial upgrader facilities, including SDA unit, can be built at the SAGD facilities to any scale, and the liquid asphaltene can be trucked or railed to a larger central FTCrude® Bottoms Refinery Complex in a central Alberta location. FT SynDiesel® can be marketed in the Western Canadian domestic market with significant financial benefits.

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Appendix

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Nomenclature

CDN – Canadian
USA – United States
FTCrude® - Fischer-Tropsch Crude- Registered Trademark of Expander Energy Inc.
SynDiesel®- FT synthetic Diesel - Registered Trademark of Expander Energy Inc.
SynJet™ - FT synthetic Jet Fuel - Registered Trademark of Expander Energy Inc.
PUB – Partially Upgraded Bitumen
CO_2 – Carbon Dioxide
CO – Carbon Monoxide
H_2 – Hydrogen
O_2 – Oxygen
COS – Carbonyl Sulfide
H_2S – Hydrogen Sulfide
GHG – Greenhouse Gases
API Gravity – American Petroleum Institute Gravity Index
NGL – Natural Gas Liquids
LPG – Propane & Butane Liquid
RFG – Refinery Fuel Gas
BTPY – Billion Tonnes per Year
MTPY – Million Tonnes per Year
MMSCFD – Million Standard Cubic Feet per Day
SCO – Synthetic Crude Oil
GJ – Metric Thermal Unit
BTU – British Thermal Unit
WTI – West Texas Intermediate – North American Crude Index
Brent – World Crude Index
WCS – Western Canadian Select DilBit
DilBit – Bitumen with Diluent added
CCR – Conradson Carbon Number – measure of coking material
TAN – Measure of naphthenic acid content
Vol Yield % - volume product yield from bitumen
Bbl – Barrel = 42 US gallon
BPD – Barrels per day
F-T – Fischer Tropsch Process
GTL – Gas to Liquids
SAGD – Steam Assisted Gravity Drain Process
SDA – Solvent De-Asphalting Unit
DAO – De-asphalted Oil
ADU – Atmospheric Distillation Unit
TIC – Total Installed Cost
IRR – Unlevered Project Rate of Return
NPV – Net Present Value
CAPEX – Project Capital Cost
OPEX – Project Annual Operating Costs

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APPENDIX

Table 1.0 Current Partial Upgrading Technologies

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PROCESS STEPS	SDA + RFCC	Pyrolysis + Coking	SDA + Coking	SDA	Thermo-cracking+SDA	SDA + Gasification + FT
BYPRODUCTS	Asphaltene + Coke	Coke	Asphaltene + Coke	Asphaltene	Asphaltene	NONE
EST SCO YIELD (vol%)	75-80	75-85	75-85	65 - 85	75-85	110 to 130

Figure 1.0 FTCrude® Partial Upgrader Schematic

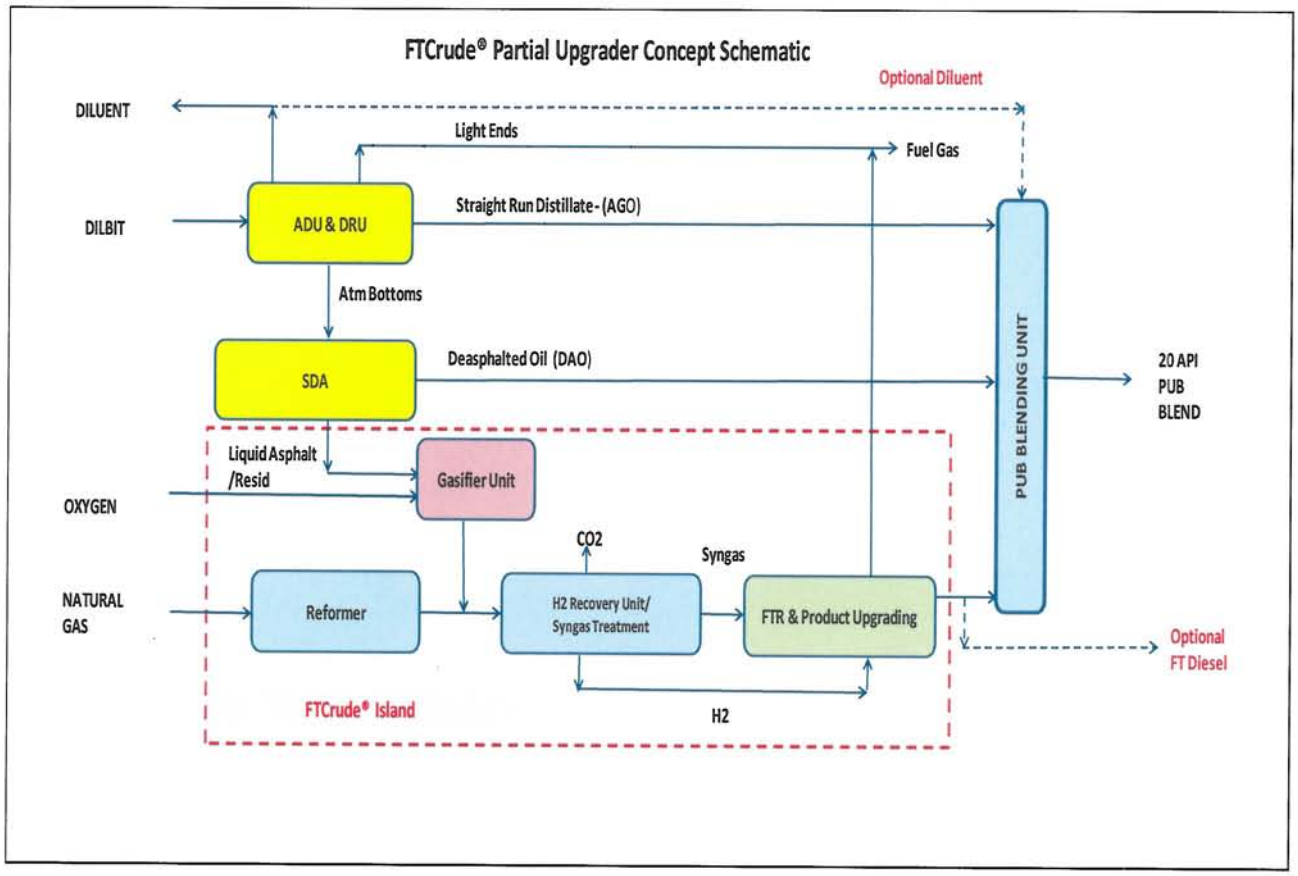

Table 2.0 Partial Upgraded Crude (PUB) Test Results

Blend Name	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Rail/Truck/ Marine Blend	Deasphalted Dilbit
Components (wt%)						
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FT Sample A			31.5	34.6	18.1	
Diluent (additional)	17.5	18.0				29.7
Raw Bitumen	82.5				42.6	
Dilbit		82.0				
Total	100.0	100.0	100.0	100.0	100.0	100.0
Properties						
Viscosity cP at 10C	11,600	338	383	225	16,176	909
Viscisty CP at 30 C	1,740	102	122	68	2,475	237
Density kg/m3 at 10C	967.9	928	921.8	910	970.6	949.1
API Gravity	14.7	20.9	22	24	14.3	18
Sulphur	4.70%	3.87%	3.19%	2.92%	4.34%	3.44%
Asphaltenes (n5 solvent)	18.30%	16.60%	5.66%	4.74%	9.82%	2.94%
Microcarbon (w/w)	12.90%	11.42%	6.01%	6.23%	7.02%	5.57%
Nickel (mg/kg)	73	63	30	28	47	14
Vanadium (mg/kg)	190	170	78	75	126	35
Distillation (F)						
IBP	36	1	28	0	60	17
50%	557	443	420	398	484	439
80%	n/a	608	588	577	616	595
FBP	n/a	741	738	738	741	739

Table 3.0 Volume Fractions of PUB Blends

Based on feed 100,000 bpd Bitumen	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 - Blend	Marine/Rail Blend	Deasphated Bitumen Dilbit
Blend Density (API)	14.7	20.9	22	24	14.3	18
Components (BPD)						
Deasphalted Oil			51,617	49,198	28,711	51,617
Straight Run Distillate			23,800	23,800	13,238	23,800
FT Sample A			45,964	50,816	25,566	
Diluent (additional)		36,653				37,303
Bitumen	100,000	100,000			44,377	
Diluent (as received)	29,200	29,200				
TOTAL PUB	**129,200**	**165,853**	**121,381**	**123,814**	**111,892**	**112,720**
Diluent	29,200	65,853	0	0	0	37,303
Vol % Diluent	22.6%	39.7%	0.00%	0.00%	0.00%	33.1%

Table 4.0 FTCrude® PUB Upgrader Stream Balance

100,000 bpd Bitumen feed - FTCrude® Partial Upgrader	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Marine/Rail Blend	Deasphated Bitumen Dilbit
Feed (BPD)						
Bitumen	100,000	100,000	100,000	100,000	100,000	100,000
Diluent	29,200	65,853				37,303
Natural Gas (mmscfd)			220	250	122	220
Products (BPD)						
Dilbit (max 350 cSt @ 15 C)		165,853				
DA Bitumen/Diluent (20 API)						112,720
PUB (max 350 cSt @ 15 C)			121,381	123,814		
Marine/Rail Blend (14-16 API)	129,200				111,893	
Separate FT Product Syndiesel®						45,964
TOTAL PRODUCTS	129,200	165,853	121,381	123,814	111,893	158,684
Product Yield to Bitumen (%)	129%	166%	121%	124%	112%	121%

Table 6.0 FTCrude® PUB Upgrading Commercial Value Comparison

100,000 bpd FTCrude® Bitumen partial upgrader - $/year revenue	Dilbit as received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Marine/Rail Blend	Deasphalted Bitumen/Dilbit + FT SynDiesel®
Input Costs ($/day)						
Bitumen	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000
Diluent	$1,314,000	$2,963,385				$1,678,635
Natural Gas			$660,000	$750,000	$366,000	$660,000
Oxygen Cost @$50/MT			$110,000	$110,000	$74,250	$110,000
Fixed OPEX @ 4% CAPEX			$315,152	$315,152	$218,182	$315,152
Total Feed ($/day)	**$3,314,000**	**$4,963,385**	**$3,085,152**	**$3,175,152**	**$2,658,432**	**$4,763,787**
Products ($/day)						
Dilbit (max 350 cSt @ 15 C)		$6,219,488				
DA Bitumen/Diluent (20 API)						$4,438,350
PUB (max 350 cSt @ 15 C)			$5,006,966	$5,107,328		
Ship/Rail Blend (14-16 API)	$4,602,750				$3,986,188	
FT Syndiesel® Sales						$4,389,351
Total Products ($/day)	**$4,602,750**	**$6,219,488**	**$5,006,966**	**$5,107,328**	**$3,986,188**	**$8,827,701**
Added value ($/day)	$1,288,750	$1,256,103	$1,921,815	$1,932,176	$1,327,756	$4,063,914
$ MM @ 330 days	$425	$415	$634	$638	$438	$1,341
Transport Tarriff ($5.00/BBL)						
Est Shipping Cost ($/day)	$646,000	$829,265	$606,905	$619,070	$559,465	$563,600
EstAnnual Shipping Cost ($M/yr)	$213	$274	$200	$204	$185	$186
Est Capex ($MM US)			$2,600	$2,600	$1,800	$2,600
Project Unlevered IRR (%)			20.0%	20.1%	20.0%	36.6%
Return NPV@15%	$1,586	$1,065	$871	$892	$600	$4,381

Figure 2.0 Typical Crude Oil Assays

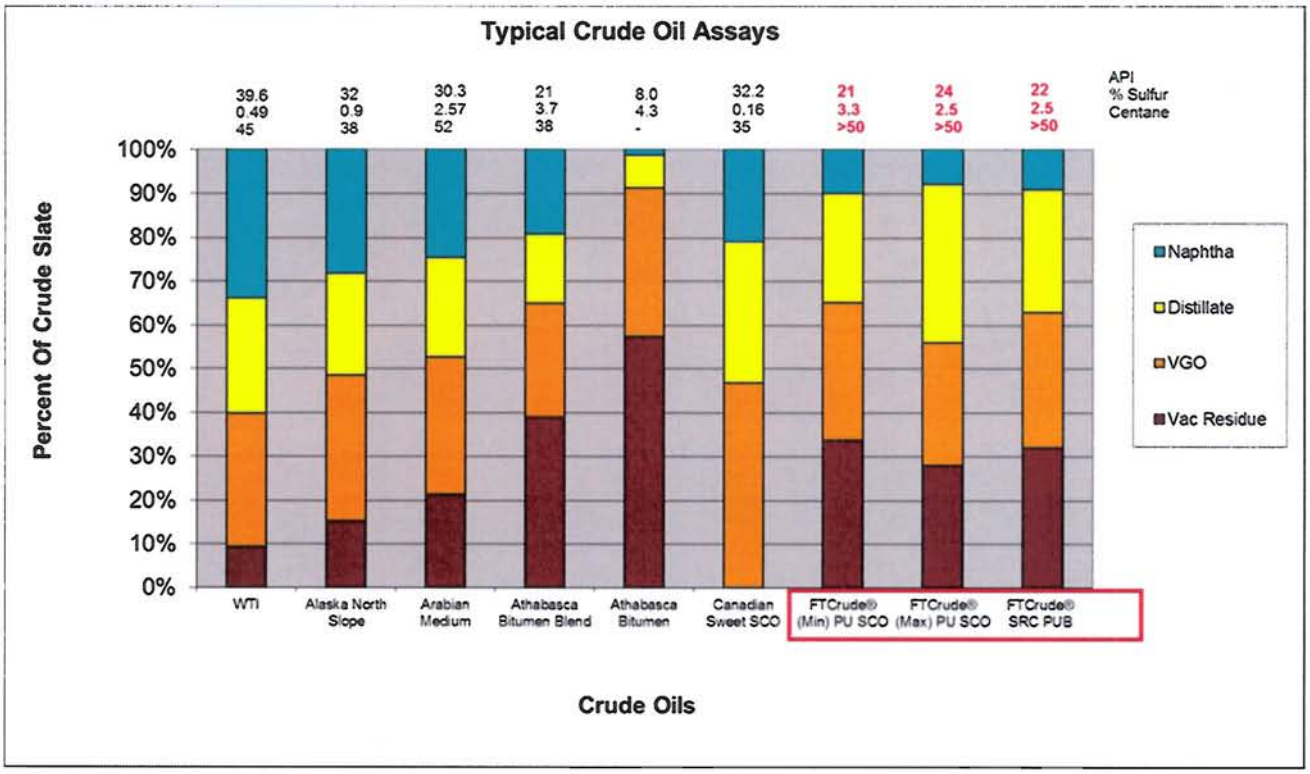

Table 3.0 SRC PUB Crude Oil Assays