

WORLD
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**Bitumen Partial & Targeted Upgrading:
the Next Step**



EXPANDER ENERGY INC.
INNOVATIVE ENERGY SOLUTIONS

CALGARY, ALBERTA, CANADA

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Introduction

- What is next step for Alberta Bitumen?
- Status of Current Partial Upgrading concepts
- FTCrude® Partial Upgrading Concept
- Saskatchewan Research Council (SRC) PUB Pilot Work
- Targeted PUB blends and related economics
- Conclusions and Observations

Alberta Bitumen Issues

- Bitumen relies on the addition of diluent for transporting
 - DilBit/SynBit is costly
 - Diluent recovery and recycling is costly
 - Limited Diluent availability
- Lack of pipeline capacity and low pipeline efficiency using high diluent content
- Environmentally undesirable components of heavy metals, sulfur, olefins and petcoke
- Incompatible feedstock for existing refineries

Will New Bitumen Upgraders be in Alberta Future?

- **Economic Drivers needed for new Upgrader projects:**
 - SCO price premium over WTI (5 to 10%)
 - High light-heavy crude cost differentials (>\$25/bbl)
- **Current Economic Concerns:**
 - Current light-heavy price differentials (\$12 to \$15/bbl)
 - Rising capital cost for Alberta based new upgrading or refining
 - Government regulations for a higher carbon tax
- **Conclusion:**
 - Alberta's economic environment is not conducive to building new grass roots Upgraders / Refineries

Partial or Targeted Upgrading


OBJECTIVES

- The basic partial upgrading process is designed to meet pipeline specifications for gravity ($>19^{\circ}\text{API}$) and viscosity ($<350\text{ cSt at }15^{\circ}\text{C}$) – to reduce or eliminate the addition of diluent
- Removes/reduces major impurities such as sulfur, micro-carbon, heavy metals and acidity
- Produces a crude oil quality compatible with current desirable refinery feed requirements
- Significantly reduce CAPEX and OPEX costs compared to full upgrading or refining in Alberta

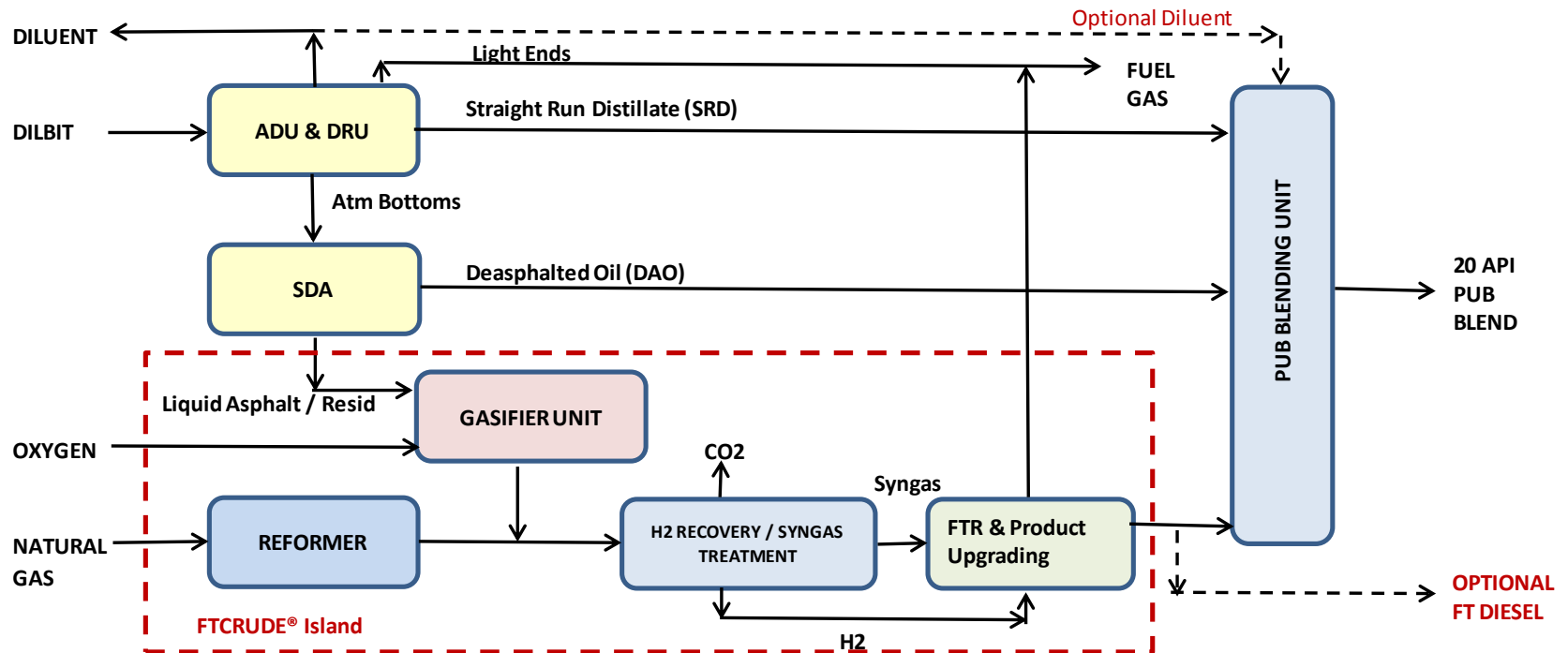
Current Partial Upgrader Technologies

- Several technologies are at various stages of development
- Most are based on thermal cracking of some fraction of the bitumen or removal of asphaltenes:
 - Resulting in volumetric losses (10 to 30%) through waste products (asphaltenes or petcoke)
 - Thermally cracked materials tend to be unstable (solids formation) & contain olefins

Current Partial Upgrading Technologies

Process	CCU	HTL	Value Creation	ROSE	HI-Q	
Licensors	UOP	Ivanhoe	Value Creation	KBR	MEG	EXPANDER
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 - 130

FTCrude[®] Partial and Targeted Upgrading Concept



FTCrude[®] Partial Upgrader Pilot Work

- SRC study (2014) confirmed the validity of FTCrude[®] PUB concept
- Pilot Processing Steps:
 - Feed samples of DilBit (14.7 °API) and F-T liquids
 - DilBit distilled to recover diluent and obtain Straight Run Distillate (SRD) and Atmospheric Residue (AR)
 - AR was subjected to batch solvent deasphalting to produce asphaltenes and Deasphalted Oil (DAO)
 - Basic PUB blends produced from combinations of F-T liquids with DAO and SRD
 - Targeted blends produced for transport by rail or marine
 - 14-16 °API blend of deasphalted bitumen, DilBit, SRD and Diluent

Partial Upgraded Crude (PUB) Test Results

BLEND	Dilbit as Received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Rail / Marine Blend	Deasphalted Dilbit
<i>Components (wt%)</i>						
Deasphalted Oil			46.9	43.9	26.9	48.2
Straight run Distillate			21.6	21.4	12.5	22.2
FT Sample			31.5	34.6	18.1	
Diluent (additional)	17.5	18				29.7
Raw Bitumen	82.5				42.6	
Dilbit		82				
Total	100	100	100	100	100	100
<i>Properties</i>						
Viscosity cP at 10°C	11,600	338	383	225	16,176	909
Viscosity cP at 30°C	1,740	102	122	68	2,475	237
Density kg/m3 at 10°C	967.9	928	921.8	910	970.6	949.1
API Gravity	14.7	20.9	22	24	14.3	18
Sulfur	4.70%	3.87%	3.19%	2.92%	4.34%	3.44%
Asphaltenes (c5 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
<i>Distillation (°F)</i>						
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

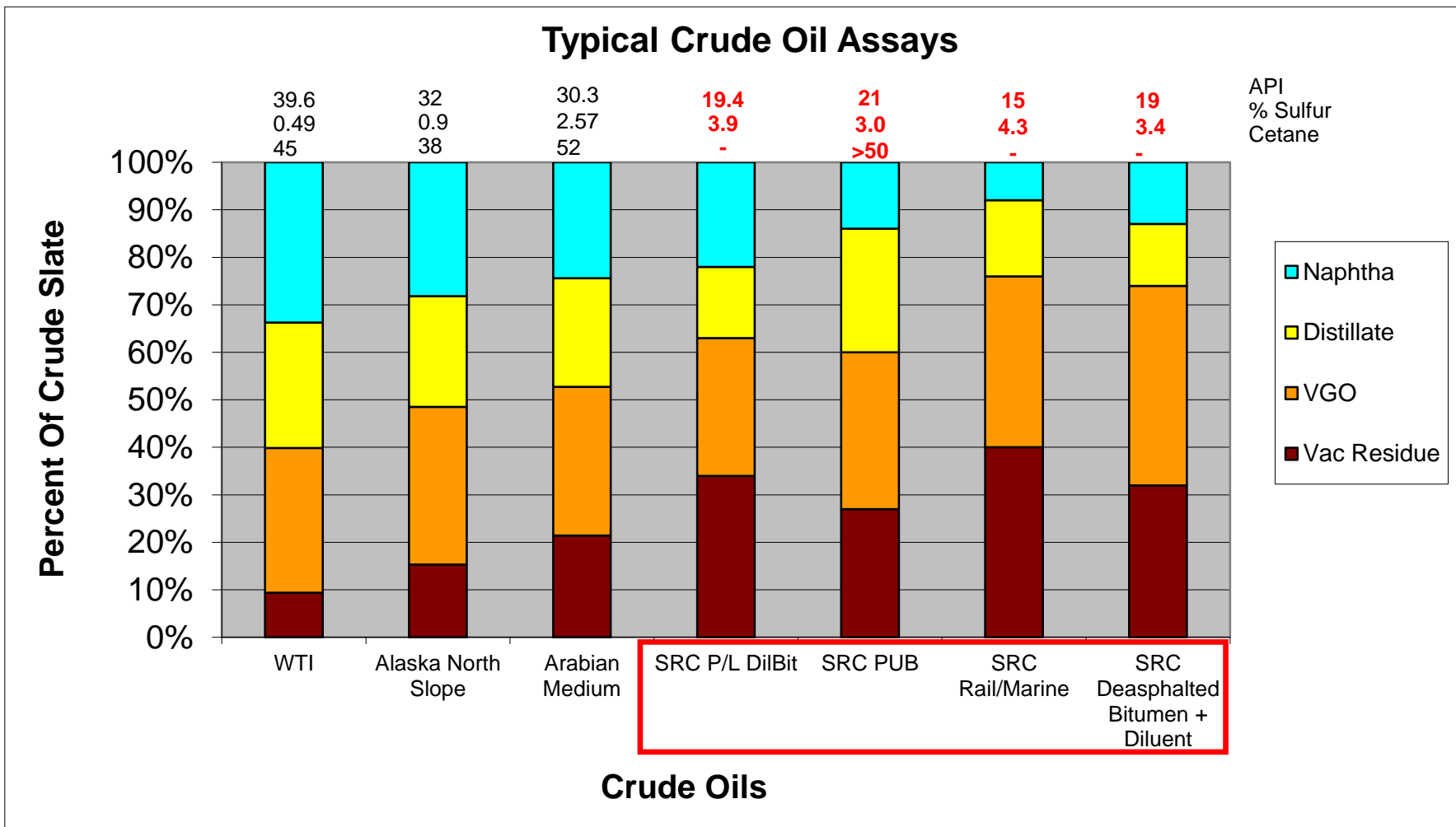
Volume Fractions of PUB Blends

FT Crude® Partial Upgrader 100,000 bpd bitumen	Dilbit as Received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Rail/Marine Blend	Deasphalted Bitumen Dilbit
<i>Blend Density (API)</i>	14.7	20.9	22.0	24.0	14.3	18.0
<i>Components (bpd)</i>						
Deasphalted Oil			51,617	49,198	28,711	51,617
Straight Run Distillate			23,800	23,800	13,238	23,800
FT Sample			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 Product	129,200	165,853	121,381	123,814	111,892	112,720
<i>Diluent</i>	29,200	65,853	NONE	NONE	NONE	37,303
<i>Vol % Diluent</i>	22.6%	39.7%	0.0%	0.0%	0.0%	33.1%

PUB Blends - Feeds & Products

100,000 bpd Bitumen Feed-FTCrude® Partial Upgrader	Dilbit as Received	Pipeline Dilbit	PUB 1 Blend	PUB 2 Blend	Marine/Rail Blend	Deasphalted Bitumen Dilbit
<i>Feed (bpd)</i>						
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
<i>Products (bpd)</i>						
Dilbit (max 350 cSt at 15°C)		165,853				
DA Bitumen/Diluent (20°API)						112,720
PUB (max 350 cSt at 15°C)			121,381	123,814		
Marine/Rail Blend (14-16°API)	129,200				111,893	
Separate FT Product - SynDiesel®						45,964
<i>Total Products</i>	129,200	165,853	121,381	123,814	111,893	158,684
Product Yield to Bitumen (%)	129%	166%	121%	124%	112%	121%

Typical Crude and Blend Comparisons



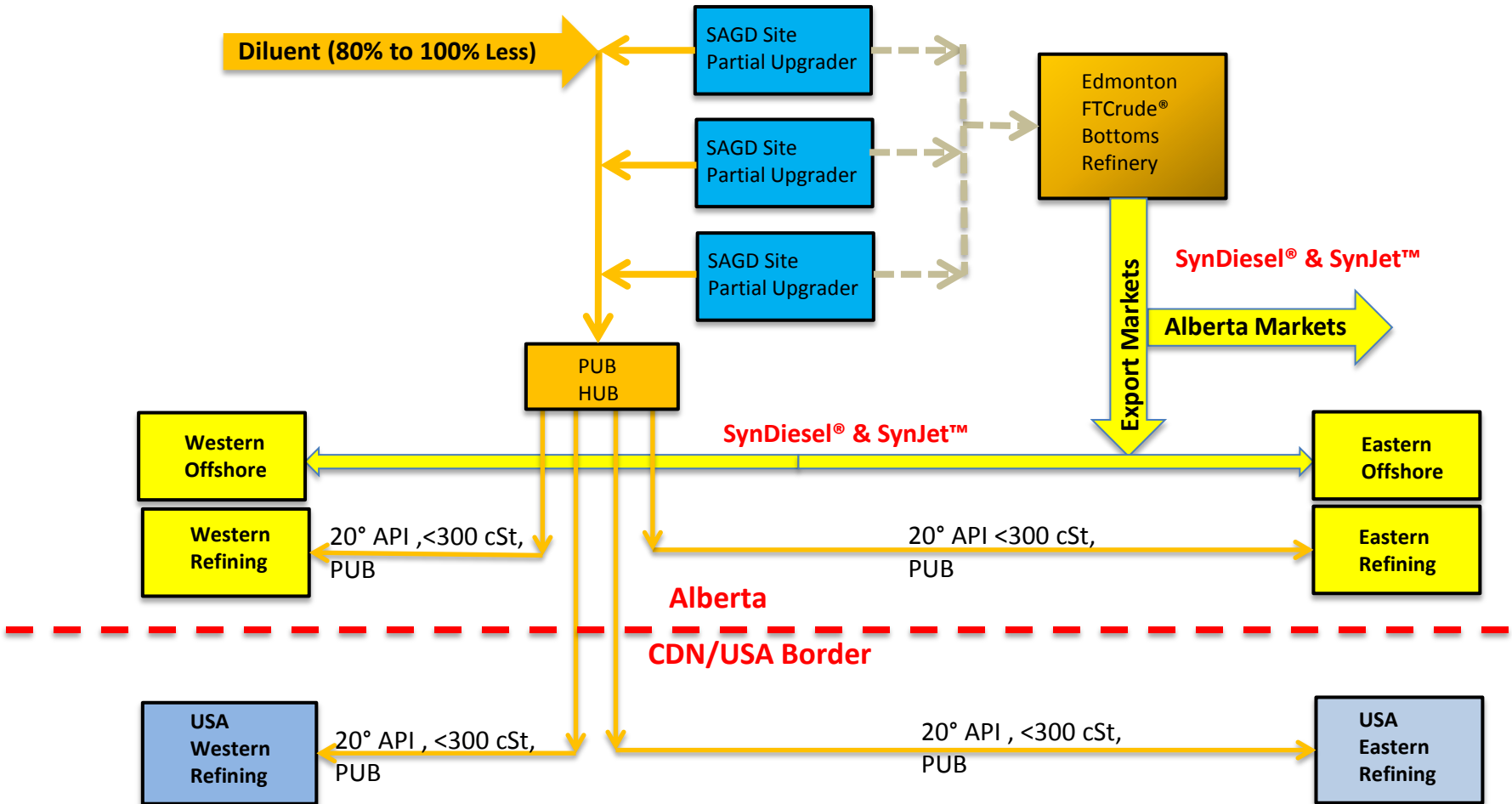
Commodity Pricing Assumptions

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	

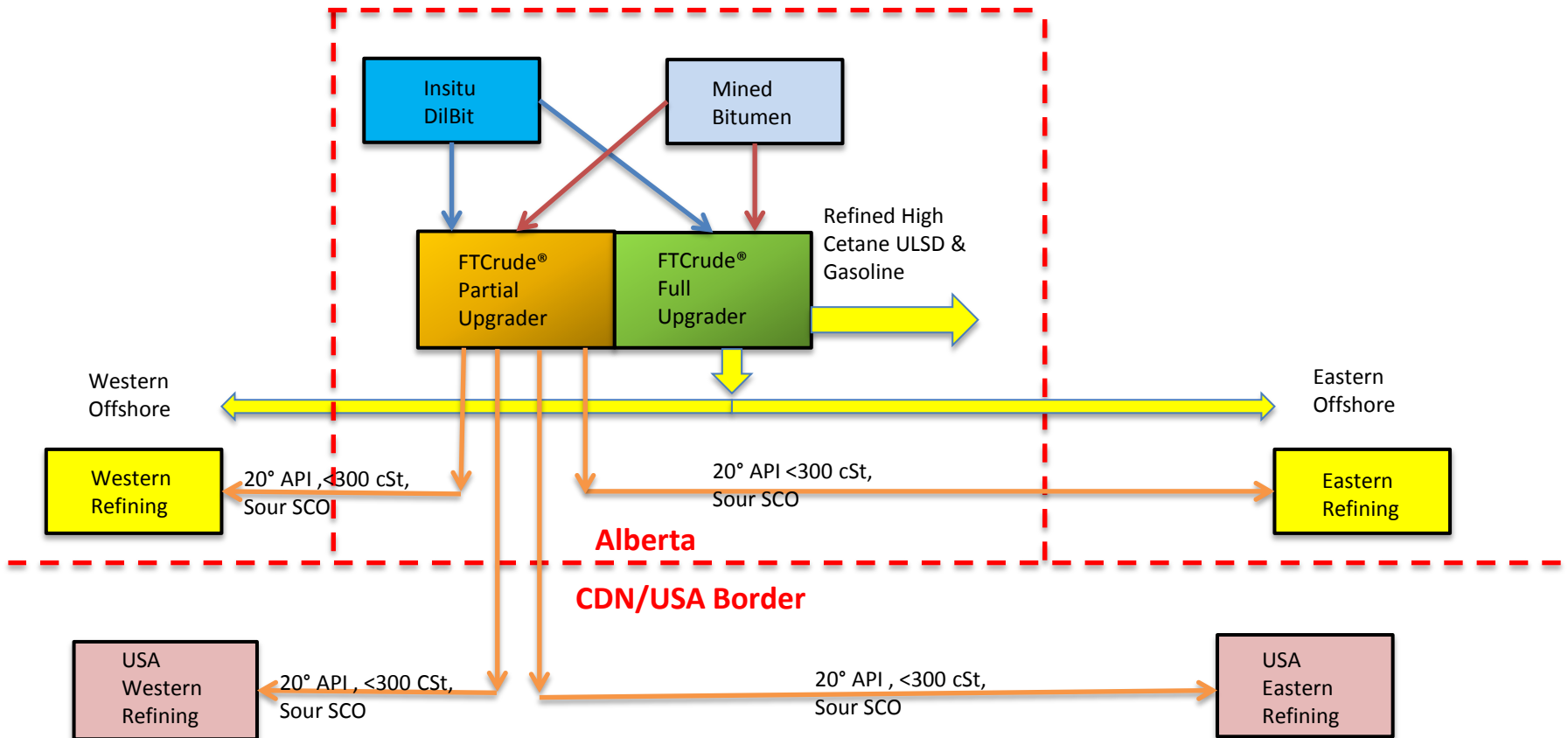
FTCrude® PUB Value Comparison

FT Crude® Partial Upgrader 100,000 bpd bitumen	PUB 1 Blend	PUB 2 Blend	Rail/Marine Blend	Deasphalted Bitumen/Dilbit + FT SynDiesel®
<i>Input Cost (\$/day)</i>				
Bitumen	\$ 2,000,000	\$ 2,000,000	\$ 2,000,000	\$ 2,000,000
Diluent				\$ 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)	\$ 3,085,152	\$ 3,175,152	\$ 2,658,432	\$ 4,763,787
<i>Products (\$/day)</i>				
Dilbit (max. 350 cSt @ 15°C)				
DA Bitumen/Diluent (20°API)				\$ 4,438,350
PUB (max 350 cSt @ 15°C)	\$ 5,006,966	\$ 5,107,328		
Rail/Ship Blend (14-16°API)			\$ 3,986,188	
FT SynDiesel® Sales				\$ 4,389,351
Total Products (\$/day)	\$ 5,006,966	\$ 5,107,328	\$ 3,986,188	\$ 8,827,701
Added Value (\$/day)	\$ 1,921,815	\$ 1,932,176	\$ 1,327,756	\$ 4,063,914
ANNUALIZED (330 days)	\$ 634,000,000	\$ 638,000,000	\$ 438,000,000	\$ 1,341,000,000
<i>Transport Tariff (\$5.00/BBL)</i>				
Est. Shipping Cost (\$/day)	\$ 606,905	\$ 619,070	\$ 559,465	\$ 563,600
Annualized	\$ 200,278,650	\$ 204,293,100	\$ 185,000,000	\$ 185,988,000
Est. CAPEX	\$2,600,000,000	\$2,600,000,000	\$1,800,000,000	\$ 2,600,000,000
Project Unlevered IRR	20%	20.1%	20%	36.6%
Return NPV @ 15%	\$871,000,000	\$892,000,000	\$600,000,000	\$ 4,381,000,000

Alberta SAGD Integrated Solution



Alberta/Canada Oilsands Integrated Solution



Conclusions

- **Full Bitumen Upgraders:**
 - Not economically feasible in Alberta for near future
- **Partially Upgraded Bitumen (PUB) Advantages:**
 - Pipelineable without diluent - No Diluent recycle required
 - PUB is significantly higher in distillate content and lower in sulfur, heavy metals, TAN and CCR compared to regular DilBit.
 - Exhibits high carbon retention - reduction of CO₂ emissions
 - Increase in product volume yield (up to 30%)
 - Partial or Targeted Upgrading can meet specific refinery feedstocks
 - No waste products of petcoke, asphaltenes and HFO
 - Partial Upgraders can be built as multiple satellite facilities (as low as 10,000 bpd) or as centralized plants (>50,000 bpd)



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Thank you

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