PARTIALLY UPGRADED BITUMEN (PUB) TECHNOLOGY
... RE-ENGINEERING CRUDE OIL QUALITY IN A CARBON CONSTRAINED WORLD

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This presentation was prepared by the presenter in his personal capacity.
The opinions expressed in this article are the author’s own and do not reflect the view of the Suncor or CCQTA.
Discussion Themes

- What is PUB? (Partial Upgraded Bitumen)
- Economic Drivers
- Technologies Overview
- Industry Status and CCQTA (COQA?) Roles
- Logistics Briefing (time permitting)

Fungible vs Specialty Cracked Product Movement
Potential New Crude Commodity Class

Acknowledgements to Jacobs Consulting (Bitumen Partial Upgrading 2018 Whitepaper AM0401A) and Alberta Innovates (Murray Gray), Canmet Energy, CCQTA
Partially Upgraded Bitumen Defined

- A majority of the bitumen produced from Alberta’s oil sands is shipped as diluted bitumen utilizing 20-33 vol% diluent to meet pipeline transportation requirements.

High diluent use imposes significant costs to bitumen producers, and adds to the ongoing limits issues with existing pipeline capacity infrastructure.

- Expanding the existing 1M bpd capacity of FULL Bitumen upgrading to Sweet Synthetic Crude Oil (SCO) has proven to be too capital and energy intensive over the past decade for further expansion.

- Oil Sands Producers and the Government of Alberta are actively developing new technologies for just enough (partial) upgrading of bitumen to meet pipeline specifications and minimize downstream processing to optimize investment costs. The first generation of demonstration plants and full-scale process plants are to come online during the period 2019-2025.

Partial upgrading is loosely defined as any combination of bitumen processing for reduced diluent addition to meet pipeline specifications.

Problem: Low Bitumen Netbacks
- High cost of production
- Low value for the product
- Limited takeaway capacity

Solution: Partial Upgrading
- Reduce/eliminate blending
- Improve quality
- Reduce exported volume

Figure 2.1: Cost of Diluent in Transporting Bitumen

*Assumes diluent price of US$50/bbl at production site; c/dilbit price of US$35.8 at USGC; and pipeline tariff of US$9.2/bbl from production site to USGC. Quality changes from partial upgrading are not considered in this figure.

Jacobs Bitumen Partial Upgrading 2018 Whitepaper
AM0401A
Economic Drivers

Existing Pipelines full and apportioned
New Pipelines delayed
Interim Rail growth can be problematic

We need to better optimize monetized Bitumen yield vs pipeline capacity
Economic Drivers

Well to wheel lifecycle

<table>
<thead>
<tr>
<th>Resource</th>
<th>Higher Value based on higher Quality</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilsands</td>
<td>Bitumen</td>
<td>sweet SCO</td>
</tr>
<tr>
<td></td>
<td>dilbit high TAN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>dilbit low TAN</td>
<td></td>
</tr>
<tr>
<td>Conventional Offshore</td>
<td>Conventional Tight Oil Offshore</td>
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<tr>
<td></td>
<td>... Resource</td>
<td></td>
</tr>
<tr>
<td></td>
<td>heavy sour benchmark</td>
<td></td>
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<tr>
<td></td>
<td>medium sour benchmark</td>
<td></td>
</tr>
<tr>
<td></td>
<td>light sweet benchmark</td>
<td></td>
</tr>
</tbody>
</table>

Value Chain & Capital Costs
Economic Drivers

Upstream value extraction

- Bitumen
  - Dilbit high TAN
  - Dilbit low TAN

- Bitumen
  - dilbit high TAN

- Bitumen
  - dilbit low TAN

- Bitumen
  - BP Whiting: 100 mbd $3.8B
  - Marathon Detroit: 40 mbd, $2.2B

- Bitumen
  - Redwater upgrader/refinery: 80 mbd (50 mbd bitumen), ~$9B

- Conventional
  - Tight Oil
  - Offshore

- Resource
  - Midland basin D&C cost ~$6 million for EUR of 300kbbl per well ($30 capex/discounted barrels)

SAGD Econ ($25-40K/flowing bpd)
SAGD: 40 mbd, 1.6B new construction

Coker Econ ($40-$50K/flowing bpd)

Upgrader Econ ($110k/flowing bpd)
finished products

Tight oil econ

Value Chain & Capital Costs
Economic Drivers

Downstream value extraction

Value Chain & Capital Costs

- Bitumen
- Dilbit high TAN
- Dilbit low TAN
- Heavy sour benchmark
- Sour SCO
- Medium sour benchmark
- Light sweet benchmark
- Sweet SCO
- Finished Products Basket

Bitumen

- dilbit high TAN
- dilbit low TAN

Medium conversion refinery

Sour SCO

Simple refinery

- sweet SCO

Deep conversion refinery

- heavy sour benchmark
- $23/bbl
- medium sour benchmark
- $18/bbl
- light sweet benchmark
- $14/bbl

Finished products
Economic Drivers

Partial upgrading targets value uplift with lower investment cost

- Partial upgrading targets value uplift to medium sour low TAN grades, with initial CAPEX estimates of 100mbd, $1.5B to $3B ($15-$30k/flowing bpd)

- The lower capex is realized through combination of vis-breaking and de-asphalting
Option to re-deploy proven technology to upstream ...

Partial upgrading adds downstream technology building blocks to upstream toolkit.

- **Physical Processing / Separation**
  - Low severity thermal cracking
  - Breaking large molecules for viscosity reduction
  - Little change to asphaltenes
  - Yield increase

- **Solvent de-asphalting**
  - Paraffinic (C3, C4, C5) Froth Treatment
  - In-situ solvent based asphaltene rejection
  - Yield loss

- **Vis-breaking**

- **Thermal Processing / Cracking**
  - High severity thermal cracking
  - Key building block of a full scale upgrader
  - Yield loss through rejection of coke

- **Delayed & Fluid Coking**
  - Thermal cracking with hydrogen addition
  - Olefin treatment reducing coke forming tendency
  - Yield increase

- **Hydro-cracking**

- **Thermal Processing / Cracking**
A few quick notes on Green House Gases and Carbon Intensity for PUB’s

Conceptual only

Assumption of Improvements/Reductions in Upstream Carbon Intensity vs SCO or SAGD Dilbits

1. Reduced Diluent demand results in less Carbon Intensity due to decreased market for Imported volumes (lower pipeline flows, less double or triple processing of diluents)

2. Asphaltene rejection in Alberta will not result in combustion of the separated high carbon, low hydrogen residue. Potential for future Bitumen-Beyond-Combustion applications for specialized asphaltene solid stream.

3. Mild Thermal Cracking / Vis-breaking significantly reduces Carbon Intensity vs Full Coking and improves Bitumen Life Cycle yield thus benefiting the “per barrel” measure. Some measure of Hydro-processing transferred to Refinery.

4. Reduced MCR/C5 Asphaltenes allows improved coker yield in Refining and thus less coke combustion.

Figure 3.5: GHG from Crude Oil Refining – Coking Based, High-Conversion Refinery

(Jacobs Consultancy, 2016)
Technology Readiness Level (TRL)

…as defined by Alberta Innovates.

A key component of this assessment is early identification of issues (operational, availability, and constructability issues) coupled with technical, engineering, and economic assessment tailored to match the quality of the available data, which can be somewhat sketchy for new and novel technologies!

<table>
<thead>
<tr>
<th>Development Stage</th>
<th>Achievement</th>
<th>Step</th>
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<tbody>
<tr>
<td><strong>Research:</strong> Research is primarily done in the lab and ranges from fundamental curiosity driven research to proof of concept in a lab setting. Theory and scientific principles are focused on specific application area to define concept. Analytic tools are developed.</td>
<td>Basic principles of concept observed and reported</td>
<td>1</td>
</tr>
<tr>
<td><strong>Development:</strong> The basic technological components are integrated for testing in a simulated environment and includes alpha testing of options</td>
<td>Component and/or subsystem validation in a laboratory environment</td>
<td>4</td>
</tr>
<tr>
<td><strong>Pilot:</strong> The prototype is tested in the field in an operational environment and is well integrated with other systems. 0.1-0.5% of commercial. Scale needs to be demonstrated.</td>
<td>Component and/or validation in a simulated environment</td>
<td>5</td>
</tr>
<tr>
<td><strong>Demonstration:</strong> The technology is being scaled up and tested in its final form and under expected conditions. Activities include the deployment of handbooks, documents, and maintenance. Typically, greater than 5% of commercial scale.</td>
<td>System/subsystem model or prototype demonstration in a simulated end-to-end environment</td>
<td>6</td>
</tr>
<tr>
<td><strong>Commercialization:</strong> The first commercial application of the technology is established; the technology is ready for widespread adoption by others.</td>
<td>Actual system completed and qualified through tests and demonstration in an operational environment</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Actual system proven through successful deployment in operational setting</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Wide scale deployment</td>
<td>10</td>
</tr>
</tbody>
</table>
Wide Boundary Bitumen Upgrading Paths : Technology Screening for PUB

Starting list of potential opportunities

1. Visbreaking /Thermal Cracking
2. Selective production (thermal solvent extraction)
3. Solvent deasphalting (SDA)
4. Increase asphaltene rejection of PFT Bitumen
5. Mild thermal cracking of PFT bitumen
6. Direct Contact Steam Gen
7. Molten sodium upgrading (MSU)
8. Mild thermal cracking (e.g. cross-flow coking) (ETX)
9. MEG HIQ® process
10. Next generation visbreaking
11. Next generation SDA/ thermal cracking combinations
12. Hydrogenated visbreaking
13. N-SOLV
14. Insitu Upgrading/Extraction
15. ESEIH Harris Microwaves
16. Insitu upgrading (Methods for mined oilsands)
17. Upgrading Additives
18. High shear upgrading (Fractal)
19. Low severity slurry phase hydrocracking
20. Value Creation upgrading
21. Cavitation technologies
22. Oxidative desulfurization (Auterra)
23. Acoustic technologies
24. Slurry phase hydrocracking
25. Ebullated bed residue Hydrocracking (RHC)/LC Finer/H-oil
26. Slurry phase residue hydrocracking
27. HCAT
28. Fluid coking
29. Ivanhoe HTL process
30. Taciuk Retort process
31. WaterBased supercritical solvent extraction
32. OrCrude process/Nexen
33. Tru process
34. Novel diluent mixtures
35. Expander Energy
36. Water based visbreaking (oremulsion)
37. Application of electrons to condition bitumen
38. Selective mining for feed fines
39. Selective mining for asphaltenes
40. PFT Bitumen

Technologies screening

Commercially proven:
X
Y
Z

Developmental (mid-TRL):
1
2
3

Multiple metrics:
Supply Cost, Margin, NPV, IRR, Capex Intensity, DPI, GHG

Mild Thermal Cracking (MTC) and/or Solvent Deasphalting (SDA) have high near / mid term deployment potential
Engineering Crude Quality Change: De-Asphalting

The use of deasphalting with partial addition of diluent gives a non-linear reduction in residue content in the De-asphalted Oil (DAO), materially lowering MCR/CCR, Sulfur, Nitrogen and metals relative to diluted bitumen.

This DAO would be more depleted in asphaltenes than recent crudes from paraffinic froth treatment (PFT) of mined bitumen (Kearl KDB and Fort Hills FRB nominally result in ~10 wt% C5A vs 17% C5A in full Bitumen), further lowering blend naphtha and upgrading residue.

Deasphalting technologies allow the removal of some or all of the asphaltenes, depending on the desired product quality and yield.

Note some technologies allows asphaltenes to be produced as a solid vs a liquid.

Figure 5.7: Solvent Deasphalting Selectivity

(Beeston, S., 2014)
Engineering Crude Quality Change: **Thermal Cracking** (mild)

Mild thermal cracking reduces the viscosity and residue content, generating distillates and light ends.

As in commercial visbreaking processes, this thermal cracking step alters the asphaltene fraction, changing its stability, and gives migration of cracked components into the distillate fractions, including aromatics, sulfur and nitrogen species.

Depending on the specific partial upgrading technology, the design of the equipment for the thermal cracking operation may give a different time-temperature history than commercial visbreaking.

Removal of some or all of the asphaltenes enables more thermal conversion of the residue without causing incompatibility in the product crude.

Any thermal cracking will give unsaturated olefins in the product, particularly in the naphtha and kerosene fractions. Some cases indicate the option of olefin conversion, using treatments such as mild hydrotreating or other catalytic conversion to reduce the olefin content and alter associated potentially undesirable qualities.
Partially Upgraded Bitumen Technology Examples

Case 1. Partial or Complete Deasphalting of Bitumen (VCI phase 1 production)

- Diluted Bitumen
- Diluent Recovery Unit
- Deasphalting
- Blending to Pipeline Specifications
- Partially Upgraded Bitumen
- Excess Diluent
- Asphaltenes to Storage or Processing

Case 2. Thermal Cracking of Bitumen (Husky HDR™ and Fractal Systems Enhanced JetShear™)

- Diluted Bitumen
- Diluent Recovery Unit
- Thermal Cracking
- Distillation
- Blending to Pipeline Specifications
- Partially Upgraded Bitumen
- Excess Diluent
- Olefin Conversion
- Naphtha + Kerosene

Diagram showing the process flow for both cases.
Partially Upgraded Bitumen Technology Examples

Case 3. Thermal Cracking and Partial Deasphalting (MEG HI-Q®)

Case 4. Integrated SAGD Emulsion Treatment and Partial Upgrading (CNOOC BituMax™)
Partial upgrading will still be a complex process

![Diagram of a Partial Upgrading Plant](Image)

- **Natural Gas**: To SMR as Needed
- **Electricity**: To SMR as Needed, To Process Energy
- **DRU as Needed**: Bitumen Upgrading Technology
- **Offsites Utilities**: Rejected material
- **Naphtha to to Hvy Gas Oil**: Gas
- **H₂S Removal & Gas Processing As Needed**: Fuel Gas, Sulfur
- **Olefin Reduction as Needed**: Treated Naphtha
- **H₂**: To Process Energy, To pipeline
PUB potential Crude Oil Qualities

Shown just as a proxy for properties of Partially Upgraded Bitumen (PUB)

Demonstration and production plants proposed for operation 2019-2025 … true assays to follow.

“perfect fit for complex Refiner seeking lower gasoline higher distillate yield”

<table>
<thead>
<tr>
<th>Property</th>
<th>Range expected for PUB technologies</th>
<th>Diluted Bitumen</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity</td>
<td>Low (19.0) - High (35)</td>
<td>21</td>
</tr>
<tr>
<td>Sulfur (wt %)</td>
<td>Low (2.0) - High (3.9)</td>
<td>4.0</td>
</tr>
<tr>
<td>K Factor</td>
<td>Low (11.2) - High (11.5)</td>
<td>11.5</td>
</tr>
<tr>
<td>TAN</td>
<td>Low (0.3) - High (1.7)</td>
<td>1.8</td>
</tr>
<tr>
<td>P-Value</td>
<td>Low (1.5) - High (3)</td>
<td>3</td>
</tr>
<tr>
<td>Overall MCR (wt%)</td>
<td>Low (4) - High (11)</td>
<td>10</td>
</tr>
<tr>
<td>LSR (C5 – 82 C)</td>
<td>Low (2%) - High (7%)</td>
<td>12</td>
</tr>
<tr>
<td>Sulfur (wt %)</td>
<td>Low (0.2) - High (1.3)</td>
<td></td>
</tr>
<tr>
<td>N+2A (Vol%)</td>
<td>Low (53) - High (77)</td>
<td>64</td>
</tr>
<tr>
<td>Kerosene (166-243 C)</td>
<td>Low (8%) - High (10%)</td>
<td>6%</td>
</tr>
<tr>
<td>Cetane Index</td>
<td>Low (30) - High (36)</td>
<td>32</td>
</tr>
<tr>
<td>Sulfur (wt %)</td>
<td>Low (1.1) - High (2.6)</td>
<td>2.2</td>
</tr>
<tr>
<td>Smoke point, mm</td>
<td>Low (23) - High (30)</td>
<td>14</td>
</tr>
<tr>
<td>Diesel (243-335 C)</td>
<td>Low (16%) - High (23%)</td>
<td>9%</td>
</tr>
<tr>
<td>Cetane Index</td>
<td>Low (36) - High (40)</td>
<td>39</td>
</tr>
<tr>
<td>Sulfur (wt %)</td>
<td>Low (2.5) - High (3.0)</td>
<td>1.5</td>
</tr>
<tr>
<td>API</td>
<td>Low (25) - High (28)</td>
<td>25</td>
</tr>
<tr>
<td>Gasoil (335-565 C)</td>
<td>Low (35%) - High (41%)</td>
<td>29%</td>
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<tr>
<td>Sulfur (wt %)</td>
<td>Low (3.3) - High (3.8)</td>
<td>3.5</td>
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<tr>
<td>K Factor</td>
<td>Low (11.2) - High (11.4)</td>
<td>11.2</td>
</tr>
<tr>
<td>Nitrogen (ppm)</td>
<td>Low (1400) - High (2900)</td>
<td>1600</td>
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<tr>
<td>VTB (565+ C)</td>
<td>Low (14%) - High (33%)</td>
<td>35%</td>
</tr>
<tr>
<td>Sulfur (wt %)</td>
<td>Low (5.5) - High (6.4)</td>
<td>6.9</td>
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<tr>
<td>Conradson Carbon Residue (wt %)</td>
<td>Low (26) - High (42)</td>
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<tr>
<td>Nickel (ppm)</td>
<td>Low (50) - High (180)</td>
<td>150</td>
</tr>
<tr>
<td>Vanadium (ppm)</td>
<td>Low (90) - High (480)</td>
<td>430</td>
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</tbody>
</table>
Industry Headlines / Focused Governmental support

Workshop on Pipeline Specifications for Partially Upgraded Bitumen
Alberta Innovates Calgary Social Committee
Tuesday, 22 January 2019 from 9:00 AM to 4:15 PM (MST)
Calgary, AB

Overview

The Partial Upgrading Program provides up to $1 billion in financial incentives to encourage companies to build 2 to 5 bitumen upgrading facilities, as part of our Made-in-Alberta plan to get more value from our resources.

Alberta giving $440 million loan guarantee to Value Creation partial upgrading project

CALGARY — The Alberta government has been negotiating with major oilsands players Suncor Energy Inc., Husky Energy Inc. and MEG Energy Corp. since late 2018 in a bid to expediently find and fund heavy oil upgrading technology that could help alleviate pressure on existing pipelines, according to documents seen by the Financial Post.

Alberta Energy Minister Marg McCuaig-Boyd authorized the province’s energy department and Alberta Petroleum Marketing Commission in November to negotiate with six companies “as soon as possible” to financially support partial upgrading projects that would lighten the province’s heaviest oil grades, according to the documents.
CCQTA planned forum and cooperative work

Industry Forums and Association alignment

- Alberta / Federal Government / Alberta Innovates advancing key issues surrounding pipeline specifications. A meeting of Industry producers/integrated oil majors, pipelines and academics occurred Jan 23, 2019 where current paradigms were raised and challenged in light of potentially new crude commodity classes for Partial Upgrading Bitumen Blends
- CCQTA was also invited to participate to bridge back to original development of the Pipeline “Olefin specification” (aka Proton NMR/HNMR spec for 1wt% max as 1-decene equivalent)
- Excellent workshop on challenging original basis for such pipeline rules and establishing future potential for management of change of this key parameter
- Commitment by industry to develop new fit for purpose standards in order to better unlock PUB technologies
  - CCQTA forum to bring together Refiners and Producers (COQA as well?!)
  - Re-open definitions of cracked product understanding all stakeholder interests
    - Challenge what processability quality is innate within olefinic containing fractions
  - CCQTA to assist and vet new standards for cracked product movement
  - Industry to work parallel path of PUB quality definition along with Pipeline Logistics and Refinery Capabilities … *ie real samples, real pilot plants, real assays*
Overview on Existing Pipeline Cracked Crude Oil Movement (Olefins containing)

- **Cracked Product currently defined as having >1 wt% olefins by HNMR**

- **Next examples used to illustrate concept of movements today by some pipelines when governed by Olefin Spec**

- **Partially Upgraded Crudes may operate like this, or my indeed be upgraded sufficiently to be classified as fungible and not be subjected to logistic restrictions.**

- **volumes are subject to pipeline and tankage specifics**
Pipelines: Delivered Quality (= Value)

... Quality is a variable that is to managed
... mixing of crudes are common (typical 5-20%; potentially 100% mixed)
... normally premised on standard practice of 50/50 interface cuts, and some allowed heel mixing
... fungibility of crude movements is paramount to keep oil flowing given costly tank capital
... drives common tankage and practices for “commodity types”

5. CHANGES IN QUALITY AND SEGREGATION

a. The Carrier shall endeavour to deliver substantially the same type of Crude Petroleum as that received from a Shipper, however the Carrier shall not be obligated to make delivery of the identical Crude Petroleum received by the Carrier.

b. If Crude Petroleum tendered to the Carrier is of a kind or quality that is not currently being transported by the Carrier, then the Carrier shall, at the request of the Shipper of such Crude Petroleum and subject to the operating conditions of the facilities of the Carrier, endeavour to segregate such Crude Petroleum during transportation by the Carrier. In such circumstances, the Shipper shall, at the request of the Carrier, make such Crude Petroleum available in such quantities and at such times as may be necessary to permit such segregated movements.

c. Subject to paragraph (a) of Rule 12 of this tariff, the Carrier shall not be liable for any damage, loss or consequential loss resulting from a change in the density or other quality of a Shipper's Crude Petroleum as a result of the Carrier's transportation of such Crude Petroleum, including without limitation the mixing of Crude Petroleum with other Petroleum in the facilities of the Carrier.
Let’s consider a Typical Injection Cycle for a specialty/cracked crude

![Diagram of injection cycle]

- **Cracked volumes (possibly) restricted to 8,000 m³** given:
  - buffer handling requirements
  - availability of breakout tankage downstream
  - availability of delivery tankage downstream

- **Buffer material**
  - Crude compatible with Refinery and acceptable for pipeline and acceptable for scheduling
  - may be other heavy crude types received at terminal as nominated by shipper
1st Breakout

- 3,000 m³ of “core” buffer must be rolled into cracked volume (1,500 m³ per side)
- 3,000 m³ of “outside” buffer broken out to designated heavy tank (1,500 m³ per side)
- Two breakout tanks required
  - one to handle cracked material plus core buffer (11,000 m³)
  - one to handle outside buffer (3,000 m³)
1st Breakout Rebuffering

- 3,000 m³ of “outside” buffer positioned around cracked volume
  - allows for flushing of cracked volumes from tank farm piping
- Further movement requires two buffers to isolate adjacent batches from potentially contaminated “outside” buffer
  - preferred total buffer volume of 3,000 m³ (1500 m³ per side)
2\textsuperscript{nd} Breakout

- 14,000 m\textsuperscript{3} of cracked volume delivered
  - Either one large tank or two small ones

- 3,000 m\textsuperscript{3} of “outside” buffers delivered to a separate tank
2nd Breakout Rebuffering

- 3,000 m³ of “outside” buffer positioned around cracked volume
  - allows for flushing of cracked volumes from tank farm piping
- Further movement requires two buffers to isolate adjacent batches from potentially contaminated “outside” buffer
  - preferred total buffer volume of 3,000 m³ (1500 m³ per side)
3rd Breakout or Delivery

- 17,000 m$^3$ of cracked volume delivered
  - Either one large tank or two small ones

- 3,000 m$^3$ of “outside” buffers delivered to a separate tank
Need to ensure these intra-terminal lines are flushed so that no cracked product remains for next commodity use of that line
1st Breakout Rebuffering say ex the fabulously we-can-do-anything terminal at St James Terminal 😊

Typical considerations:

Cracked crude is say 5+% olefins
Pipe leg volume is 500 bbl
Considerations must be made to dilute this 500 bbl volume into any movement it contains
Generally cracked product movements are managed to reduce the % olefins in the total delivered batch to <1% olefins

As well, the re-buffering in a pipeline (size of interface) is driven by the prevention of olefins from migrating to adjacent batches (one must consider interface size given specific hydraulics of system)
Final Logistic Comments and Additional Considerations…

- Each Mainline Pipeline has a “New Commodity” approval process to follow which involves wide industry review given common tankage, tolls etc.
- Specifications are diverse and can be changed over time
- Changing major specifications in Tariffs/Tolls may require NEB/FERC approval
- Wide Industry review can take (6 months – 3 years) and requires dedicated teams of 6-20 companies
  - CRW specs were a complete creation taking 3 years, Enbridge Pooling principles took 2 years

New Crude Commodity Types are rare and generally require new receipt and breakout tankage … PUB’s may be a new crude commodity type with facilities shared amongst shippers.

Cracked product movement can be handled today premised on existing buffering methodology so no barrier to current PUB development
“So when considering such advancements as Partially Upgraded Bitumen….

Producers lead value creation but logistics and Refiners manage value retention”