Western Canadian Residue Hydrocracking

- Why Western Canada?
- What are the project drivers?
- Where are these residue hydrocracking projects?
- How are projects being executed?
- Who is making these projects a regional success?
Oilsands Overview

- Western Canadian Sedimentary Basin – Alberta & Saskatchewan
- World-scale oil reserves
  - 3rd Largest proven reserves
  - 2nd Largest heavy oil
- Production & Refining Centers
  - Fort McMurray
  - Edmonton
  - Lloydminster
  - Regina

Source: CAPP
Regional Connectivity

- Bitumen requires upgrading or dilution for transport
- Upgraders convert bitumen into synthetic crude oil (SCO)
  - Coking
  - Residue Hydrocracking
- Facilities include secondary upgrading and refining
Project Drivers

Pros
- Politically friendly
- Investment friendly
- Infrastructure
- Mature industry
- Technical expertise
- Available workforce

Cons
- Land-locked
- Pipeline Constrained
- Capital Cost (winterization, labor)
- Investment Competition
- ‘Dirty oil’ image
# Overview of Western Canadian Upgraders

<table>
<thead>
<tr>
<th>UPGRADE:</th>
<th>MILDRED LAKE</th>
<th>UG 1&amp;2</th>
<th>SCOTFORD</th>
<th>HORIZON</th>
<th>LONG LAKE</th>
<th>NW REFINERY</th>
<th>LLOYDMINSTER</th>
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</thead>
<tbody>
<tr>
<td>OPERATOR:</td>
<td>SYNCRude</td>
<td>SUNCOR</td>
<td>SHELL</td>
<td>CNRL</td>
<td>CNOOC</td>
<td>NWR</td>
<td>HUSKY</td>
</tr>
<tr>
<td>BITUMEN FEEDSTOCK:</td>
<td>Mildred Lake &amp; Aurora North</td>
<td>Base Plant, MacKay River &amp; Firebag</td>
<td>Muskeg River &amp; Jackpine</td>
<td>Horizon Mine</td>
<td>Long Lake SAGD</td>
<td>CNRL Cold Lake &amp; BRIK</td>
<td>Cold Lake</td>
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<tr>
<td>CAPACITY SCO (bbl/day):</td>
<td>350,000</td>
<td>357,000</td>
<td>255,000</td>
<td>240,000</td>
<td>58,500</td>
<td>50,000</td>
<td>75,000</td>
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<tr>
<td>PRIMARY UPGRADING:</td>
<td>Fluid Coking + LC-Fining</td>
<td>Delayed Coking</td>
<td>LC-Fining</td>
<td>Delayed Coking</td>
<td>OrCrude + Solvent Deasphalting</td>
<td>LC-Fining</td>
<td>H-Oil + Delayed Coking</td>
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<tr>
<td>GASIFIER:</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CARBON CAPTURE:</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PRODUCT:</td>
<td>light/sweet SCO</td>
<td>light/sweet + heavy/sour</td>
<td>light/sweet + heavy/sour</td>
<td>light/sweet</td>
<td>light/sweet</td>
<td>Diesel</td>
<td>light/sweet</td>
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<tr>
<td>YIELD:</td>
<td>85%</td>
<td>81%</td>
<td>100+%</td>
<td>85%</td>
<td>83%</td>
<td>100+%</td>
<td>90%</td>
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</table>

Statistics compiled by [www.oilsandsmagazine.com](http://www.oilsandsmagazine.com) from referenced sources.
Western Canadian Statistics Overview

- 1.4 MBPD of VDU Capacity
- 490 kBPD of Coking Capacity
- 240 kBPD of RHC Capacity

Technology Share

Statistics compiled by [www.oilsandsmagazine.com](http://www.oilsandsmagazine.com) from referenced sources.
Western Canadian Residue Hydrocrackers

<table>
<thead>
<tr>
<th>OPERATOR/OWNER</th>
<th>LOCATION</th>
<th>START-UP</th>
<th>LICENSOR</th>
<th>CAPACITY, KBD</th>
<th>TRAINS</th>
<th>CONVERSION</th>
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<tbody>
<tr>
<td>Syncrude</td>
<td>Fort McMurray</td>
<td>1988</td>
<td>CLG</td>
<td>40</td>
<td>2</td>
<td>56%</td>
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<tr>
<td>Husky</td>
<td>Lloydminster</td>
<td>1992</td>
<td>Axens</td>
<td>32</td>
<td>2</td>
<td>60%</td>
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<tr>
<td>Shell / CNRL</td>
<td>Scotford Base Plant</td>
<td>2003</td>
<td>CLG</td>
<td>92</td>
<td>2</td>
<td>75-80%</td>
</tr>
<tr>
<td>Shell / CNRL</td>
<td>Scotford Expansion</td>
<td>2011</td>
<td>CLG</td>
<td>46</td>
<td>1</td>
<td>75-80%</td>
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<tr>
<td>North West</td>
<td>Redwater</td>
<td>2018</td>
<td>CLG</td>
<td>30</td>
<td>1</td>
<td>78%</td>
</tr>
</tbody>
</table>
Scotford Upgrader
Operator: Shell
Owner: CNRL

Location: Scotford, Alberta
Start-up: 2003 Train 1 & 2
2011 Train 3 (Expansion)

RHC Features:
- 138k BPD vac residue feed
- Feed optimized with mining extraction
- LC Finer with integrated hydrotreater
- Common heavy oil stripper and product stabilizer sections
- Quest Project Add-on:
  \( \text{CO}_2 \) Capture and Sequestration
‘Carbon-free’ Residue Hydrocracking Yields
1.0 MTPY CO₂ Sequestered
35% Emissions Reduction
250,000 Vehicles per year
Shell Quest Carbon Capture Storage

- CO₂ Compressor
- CO₂ Stripper & Amine Coolers
Northwest Sturgeon Refinery
Operator: NWR
Owner: CNRL/NWR

Location: Sturgeon County, Alberta (North of Edmonton)
Start-up: 2018
RHC Features:

- 30k BPD of vac residue feed
- Distilled products sent to HCU
- Unconverted oil sent to Gasifier
- Implemented CLG reliability improvement program
Innovations and Expertise

- Land-locked reactor logistics
- Ebullated-bed pump installation & removal system
- Catalyst system receiving and loading systems
- Design Optimizations
  - Improved high pressure letdown station design and layout
  - Purge system design and distribution (tubing system)
  - Flushing Oil manifold and slops collection systems
Reactor Shipping Options

- Shipping Envelope: 14.7’ W x 16.9’ H
- Weight:
  - 500 tonnes QT TX railcar or
  - 800 tonnes Schnable car
- Heavier reactors (>1200 tonnes) shipped in 3 pieces and field welded
Reactor Logistics

Reactor Loading in Duluth, Minnesota
Reactor Field Welding

Reactor Segments Shipped by Rail and Welded in a Mobile Shop at Site
Ebullated-Pump Installation & Removal System

Pump sits in a cradle and is positioned via guides and hydraulic ram
Catalyst System Receiving and Loading Systems

- Fresh catalyst supply and spent catalyst disposal logistics
- Bulk transport
  - Rail or Truck
- Pneumatic Conveying
- Bin transport with cranes
- Local Logistics (Hoover Ferguson)
- Reclamation in Edmonton being explored
Design Optimization and Experience

- Proving ground of many firsts and lessons learned
  - Integrated fixed-bed reactor
  - Bulk catalyst handling
- Maintenance Improvements
  - Flushing oil manifolds and slop oil system design
  - Hub management program
- Reliability Improvements
  - Purge systems
  - High-pressure letdown valves
  - Instrument installations
Western Canadian Residue Hydrocracking Expertise

Network of Experience

- Engineering & Design
- Modularization
- Logistics
- Operations
- Maintenance
- Safety Systems Design and Implementation
- High pressure components and materials