



Kevin Whitehead

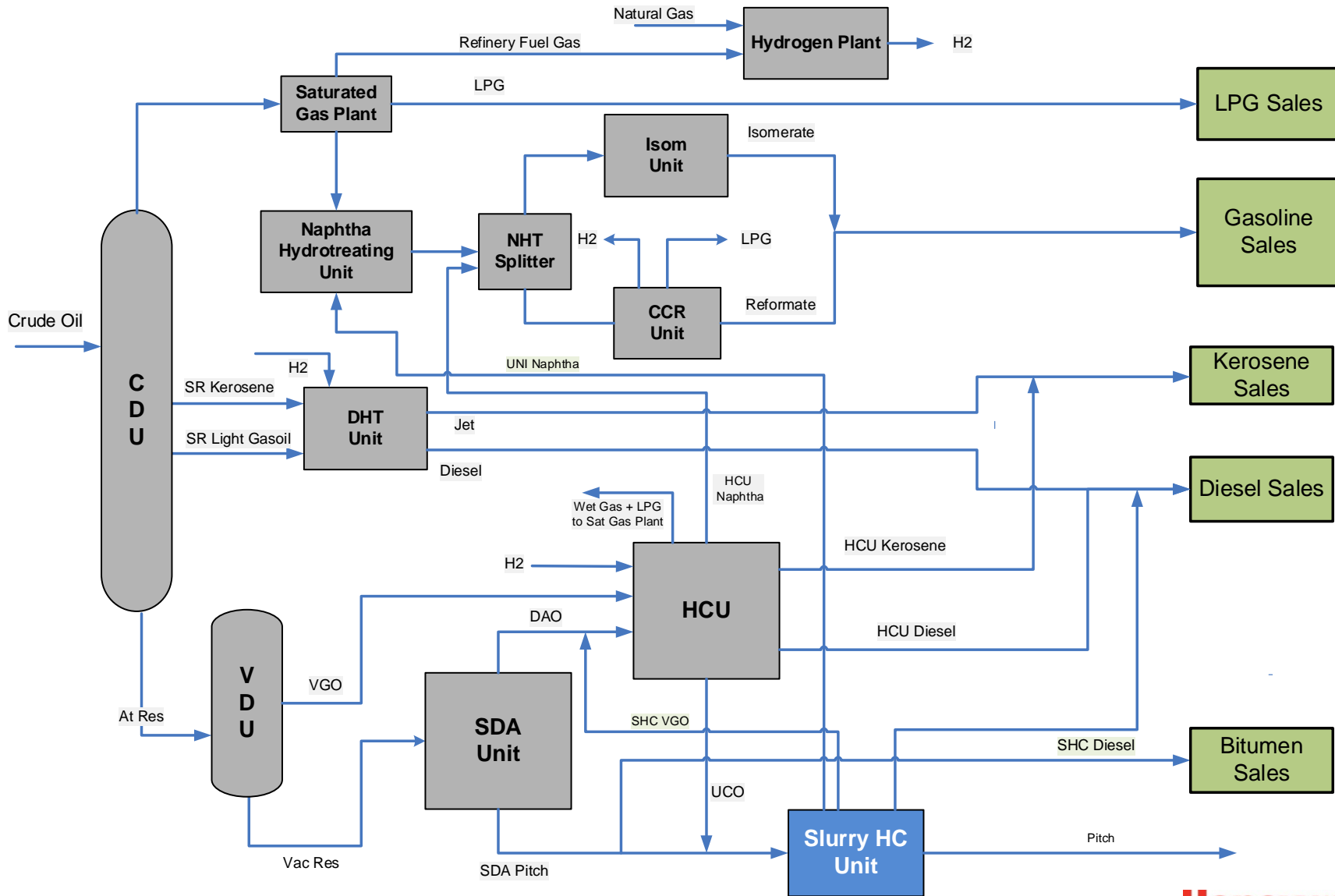
Eliminate Fuel Oil Production with Slurry Hydrocracking

Uniflex™ Process

5th December 2017 | Bottom of the Barrel Workshop | NIORDC, Tehran



Slurry Hydrocracking



Agenda



High Sulphur Fuel Oil
Market Changes



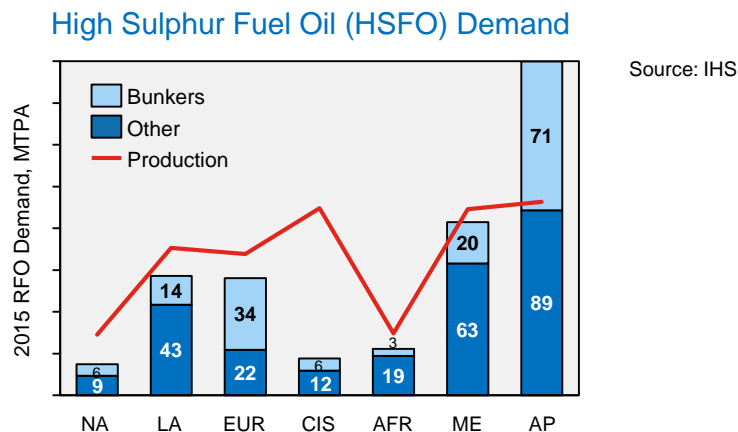
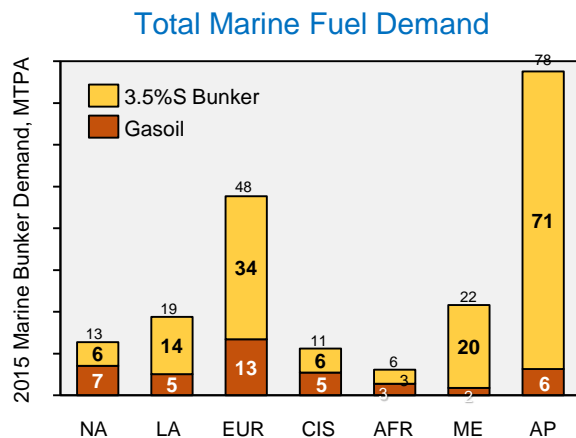
Uniflex Process



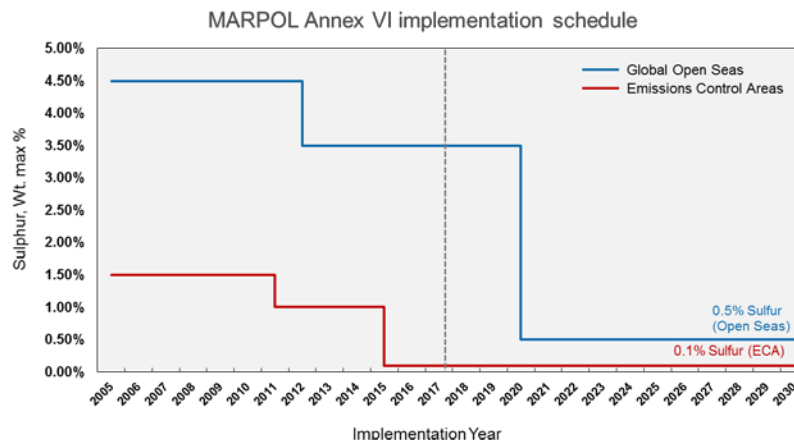
Commercial
Experience in Slurry
Hydrocracking



High Sulphur Fuel Oil Global Demand Changes from 2020



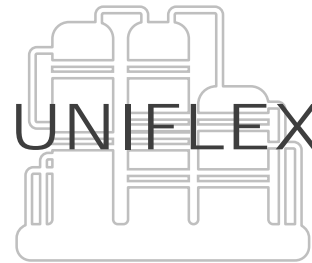
- Greatly reduced HSFO use for bunkering as a result of new regulations
- Surplus residue expected after residue conversion and power generation usage
- Will have significant impact on products & crude differentials in 2020
- HSFO expected to be priced at severe discount compared with 2016 (~40% lower)



Refinery Options to Upgrade High Sulphur Fuel Oil

Conversion Options

- Slurry HC process such as Uniflex process
 - **Good payback**
- Ebullated bed process
 - **Limited conversion**
 - **High capex**
 - **Lower payback**
- Delayed coking process
 - **Similar capex**
 - **Lower payback**



- Desulphurise HS fuel oil with process such as RCD Unionfining™ process
 - **Limited product value uplift**
- Desulphurise DAO
 - **Lowest capex, but still makes some HSFO**

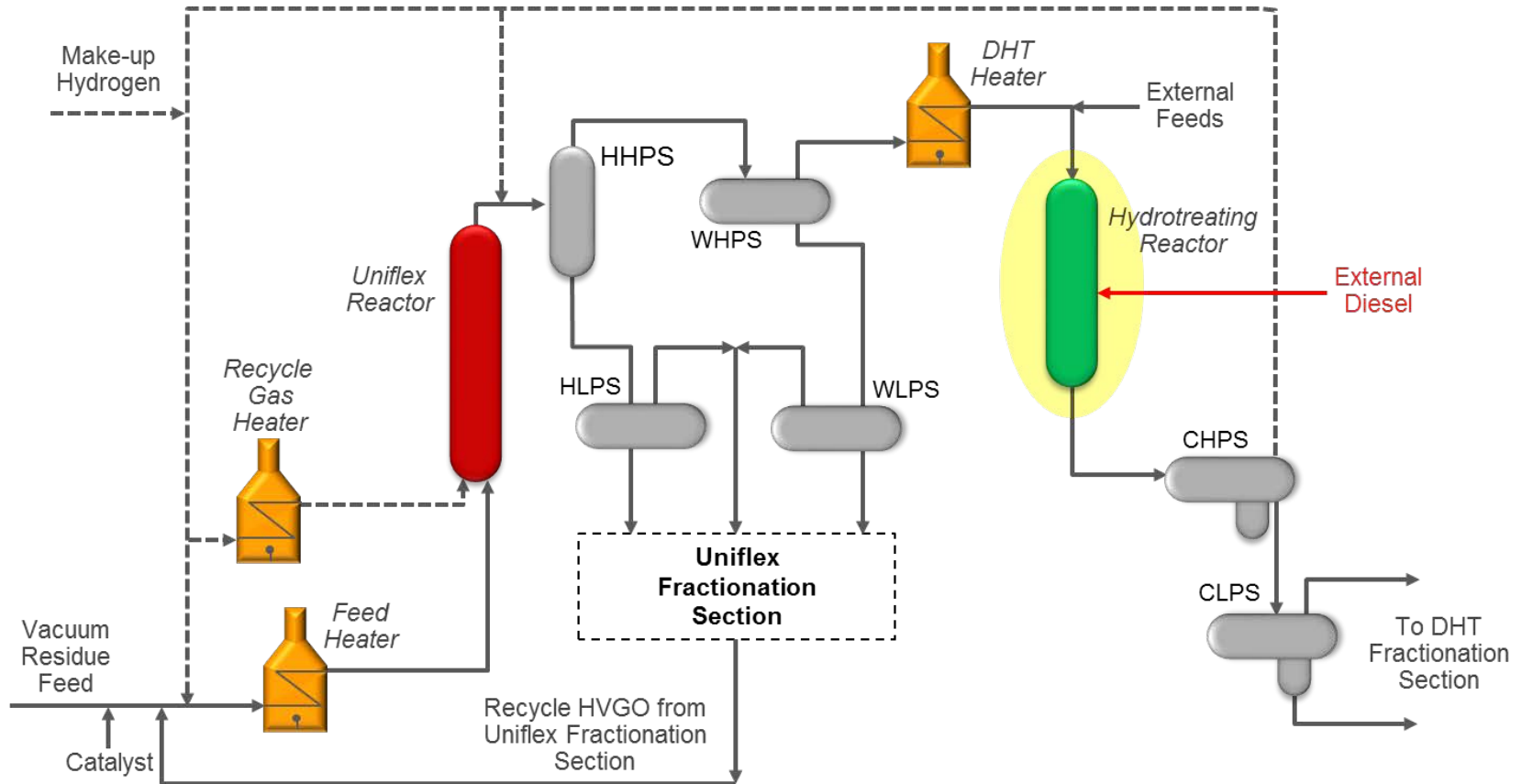
Treating Options

Uniflex process gives highest NPV based on our analysis

Slurry Hydrocracking – Uniflex Process

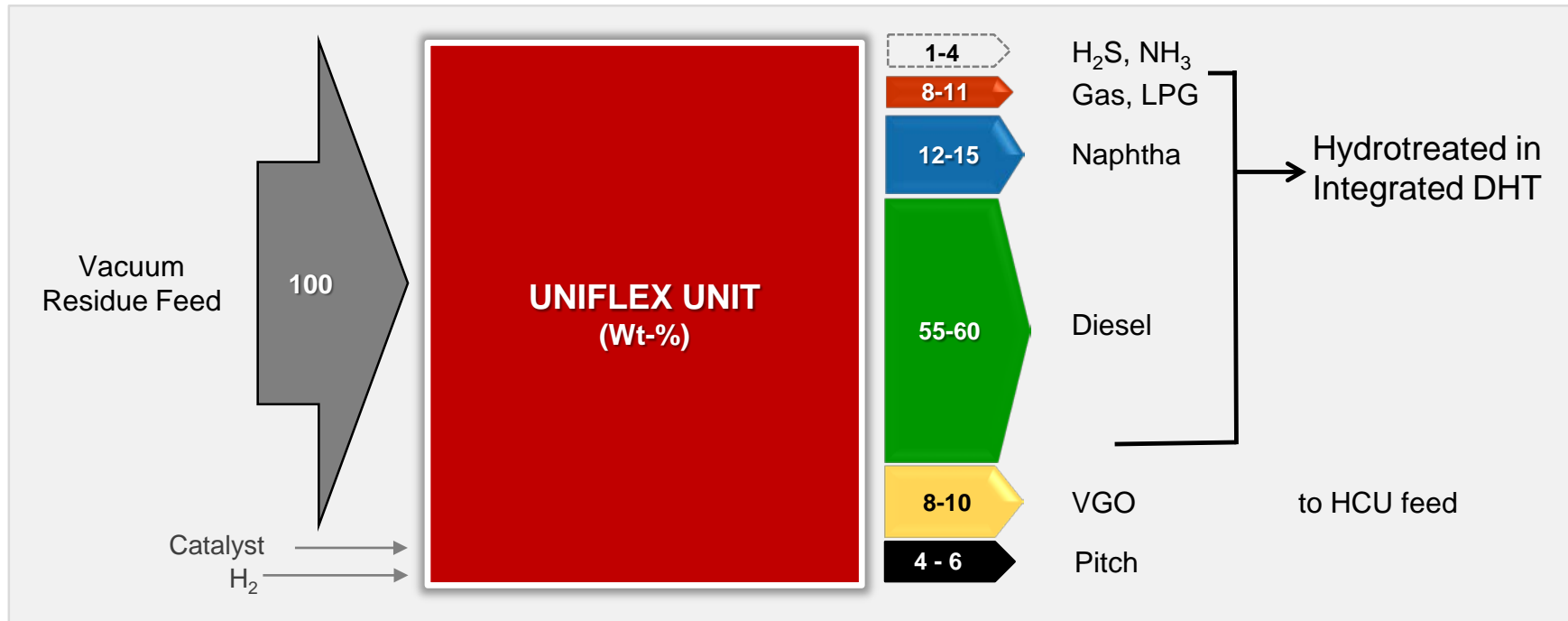
- Uniflex process is UOP's slurry hydrocracking technology
- Uniflex offering is close to that achieved in commercial unit that operated for 15 years (CANMET). High onstream factor demonstrated
- Performance:
 - Up to 95% conversion of residue
 - High yield of Euro V middle distillates
 - Low yield of VGO that can often be accommodated in existing refinery conversion units
- Process includes an integrated hydrotreater to reduce capex and produce high quality products directly from the unit
- Pressure similar to hydrocracking – similar capex
- Onsite catalyst preparation
- Effective measures taken to prevent coking and fouling in the unit
- 6 units licensed

Uniflex Unit with Integrated Hydrotreater



- Integrated hydrotreater minimises number of equipment items leading to lower capital cost
- External diesel streams could be hydrotreated to Euro 5

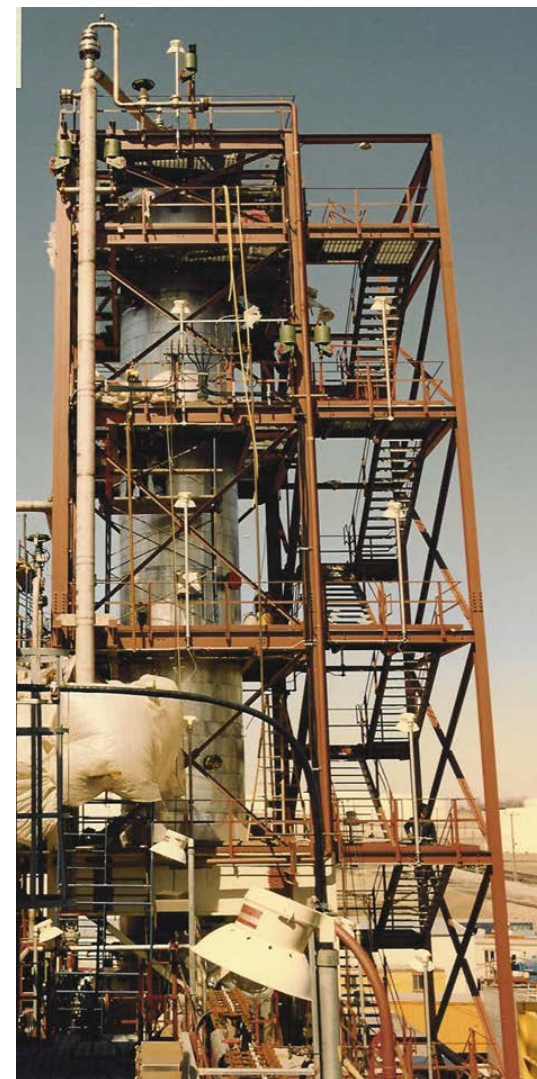
Uniflex Performance with Integrated Hydrotreater



- **95% conversion** : Higher conversion comparable to other residue conversion processes
- **Euro V Diesel** : High yield of diesel compared to other slurry processes
- **Minimum VGO** : Can be accommodated in existing conversion units
- **Naphtha** : < 1 wppm S and N
- **Pitch** : Cement Plant, Gasification Unit, Boiler/Kiln, or solidified into pellets

Uniflex commercial experience in the Petro-Canada CANMET unit

- 5000 bpsd unit operated for 15 years at Petro-Canada's Montreal Refinery
- Demonstrated excellent reliability
- Processed many residue feeds
- Also demonstrated processing of VGO, Visbroken VR, FCC Slurry Oil
- Developed design, control and analytical techniques to optimize reactor performance and reliability



Commercially proven technology

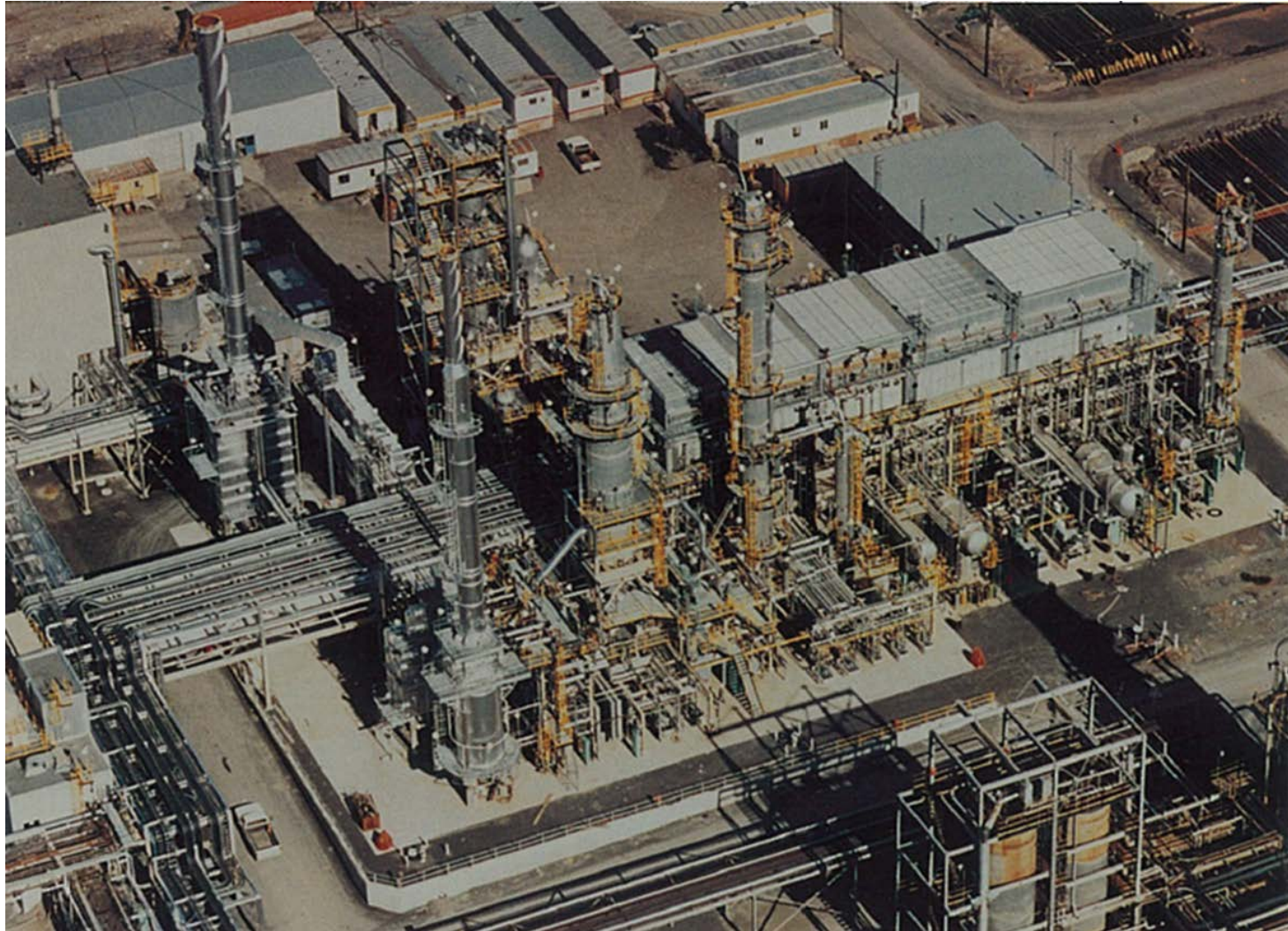
CANMET Development Timeline

- 1980s
 - Construction of the Petro-Canada Montreal 5,000 bpsd demonstration unit
 - The plant was started up in October of 1985, and testing was carried out to verify the reactor design parameters, the accuracy of the yield prediction model and the suitability of the materials of construction.
 - Having met the demonstration objectives, the unit was shut down in late 1989.
- 1990s to 2003
 - An increase in the light / heavy crude differential provided the incentive to restart the plant as a refinery unit in 1992
 - Successfully process a wide range of refinery residues from conventional crudes as well as residues from refinery conversion units
 - FCCU slurry, visbreaker vacuum tower bottoms, deasphalter bottoms residue, and poor quality gas oils from cokers and visbreakers are all upgradeable in the CANMET process.
 - Improvements in operability based on new reactor control strategy
 - Reliability was over 98% during last 5 years of operations

Petro-Canada Montreal CANMET Unit – Aerial View



Petro-Canada Montreal CANMET Unit – Aerial View



Petro-Canada Montreal CANMET Unit – Reactor Section



Typical Feeds Processed in Commercial Operation of CANMET Unit

	Cold Lake VTB	Isth-Mayan VTB	Bent Horn VTB	Iranian Light VB VR	Mene Mota VB VR
API	3.2	2.1	17.4	0.4	1.1
Sulfur	6.0	4.4	1.3	3.6	3.6
Saturates	7.9	11.2	34.8	12.5	17.9
Aromatics	19.6	32.2	47.1	34.4	27.5
Asphaltenes	20.4	33.5	1.3	36.6	34.8

- Visbroken vacuum residue from Iranian crudes successfully processed in commercial operation
- Pilot plant testing in early 1990s demonstrated conversion of over 90%wt on residue from Iranian crude

CANMET Slurry Hydrocracking – Proven Commercial Experience

- Processed a wide range of feedstocks and operating conditions
 - Achieved once-through pitch conversion of 93.5% with Cold Lake VTB feed
 - Achieved over 95% conversion on Visbroken Vacuum Residue
 - Operated successfully in most difficult operating ranges
- Developed excellent design correlations, allowing accurate scale-up
- Inherent safety and reliability proven during many refinery upsets
- Very high reliability over last 5 year period
 - Over 98% adjusted availability

UOP Heavy Oil Development Centre

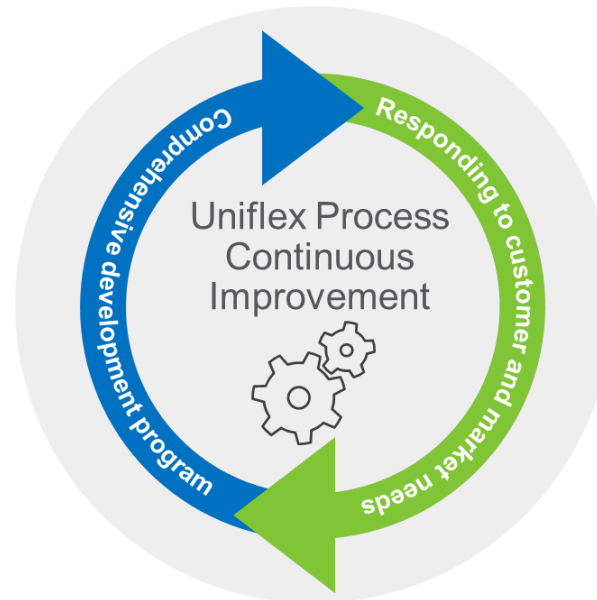
- Integrated pilot plant facilities dedicated to heavy oils development
 - High Capacity Feed Preparation/Fractionation:
 - Multi-column fractionation unit
 - Uniflex pilot plant:
 - High capacity operation with multiple reactors capable of staged operation
 - Flexible Heavy Oil Hydroprocessing pilot plant:
 - Heavy Oil Technologies fully integrated with UOP Unicracking™ and RCD and Distillate Unionfining™ pilot plants
 - Capable of high pressure (345 barg) operation with reactor configurable in all Hydrocracking and Hydrotreating modes
 - Continuous operation with online analysis operating on commercial feeds
 - **Used as basis for guarantee representations**



UOP Ltd currently not able to use these facilities for Iranian projects

Uniflex Process – Continuous Improvement

- New catalyst innovations
- Process enhancements



- High conversion to valued products
- Process design for sustained operability and reliability
- Economically efficient catalyst systems, and manufacturing capability
- Economically advantaged use for all products

Uniflex Developments

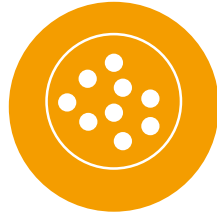
- UOP continues to invest in development of the Uniflex process
- New catalyst system
 - Prepared onsite from raw materials available on the open market
 - Low injection rate required
- Process enhancements to increase conversion and yields
 - Staged conversion
 - External reactor recirculation
 - Recycle of heavy product streams
 - Solids removal from pitch
- First unit incorporating new features expected to start up in 2019

Uniflex Benefits



10110
001
101
11010

Enables 95+ Wt-%
conversion
(525°C+ material)



Low catalyst
addition rate

- **On-site catalyst preparation**



Usable pitch

- **Low solids content, low sulfur level**
- **Fungible product (e.g. fuel, low sulfur petcoke, asphalt production)**



Euro V diesel
product

- **Integrated hydrotreating lowers overall capital cost**



