NCUT
National Centre for Upgrading Technology
'a Canada–Alberta alliance for bitumen and heavy oil research'

Oil Sands Feedstocks

C Fairbridge, Z Ring, Y Briker, D Hager

National Centre for Upgrading Technology

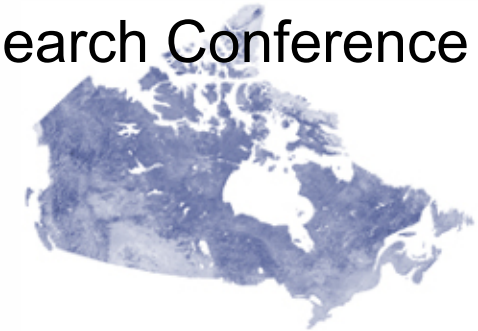
K Mitchell

Shell Canada Products

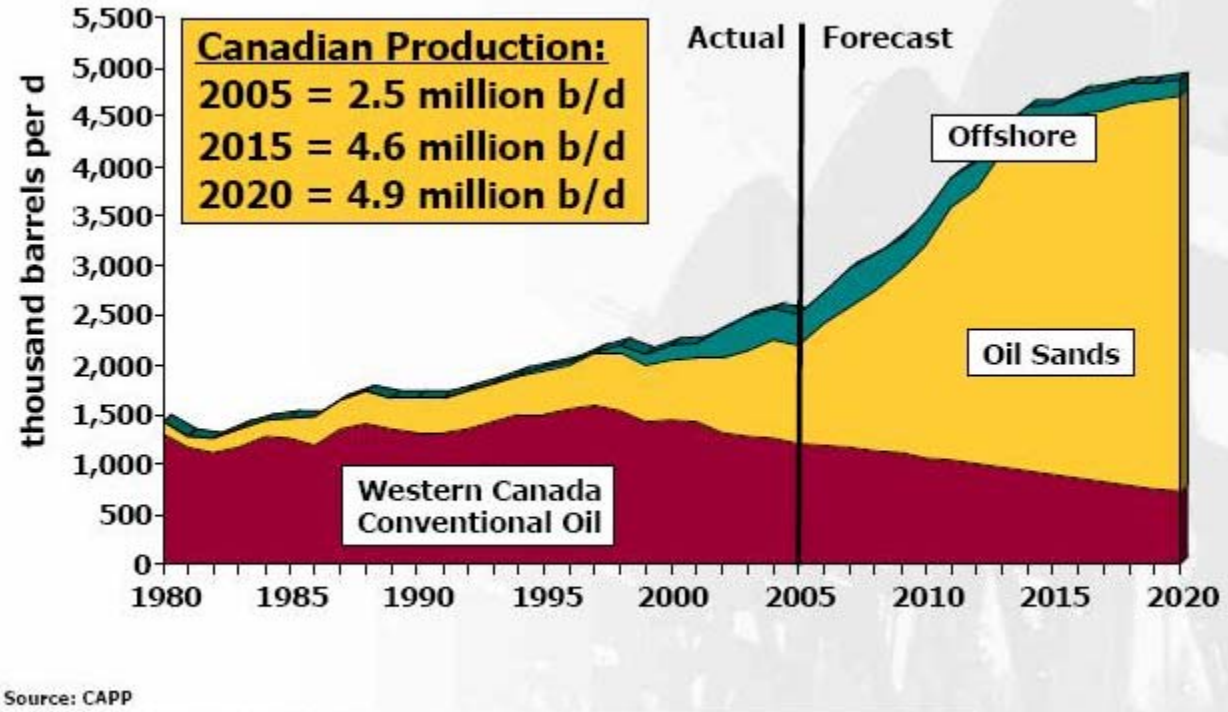
CLEAN ENERGY TECHNOLOGIES

12th Diesel Engine-Efficiency and Emissions Research Conference
August 20-24, 2006
Detroit MI

Canada



Canadian Oil Production
Conventional, Oil Sands and Offshore (CAPP)

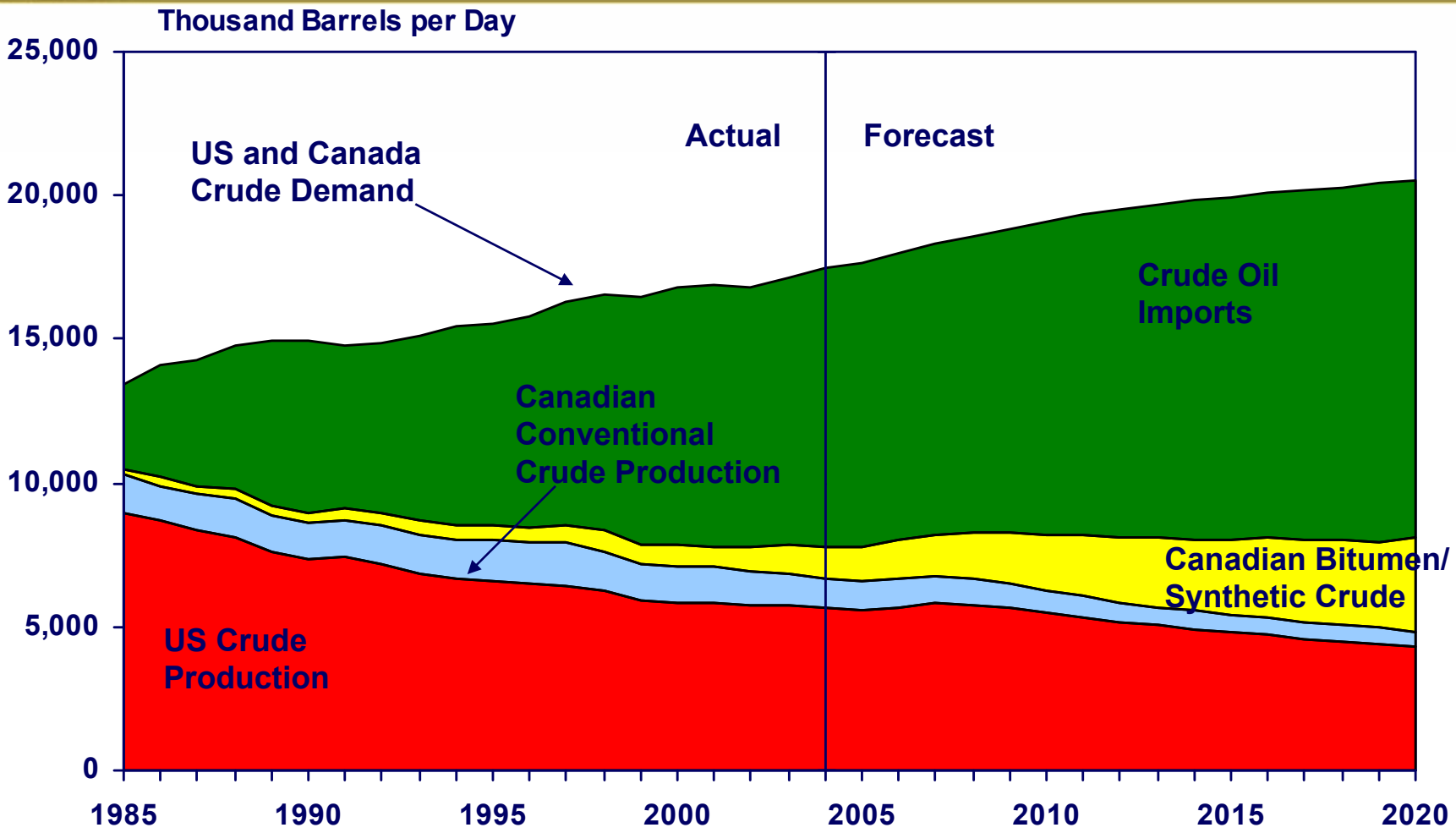


Source: CAPP

From: CAPP. Canadian Oil and Natural Gas in the North American Market. Washington DC, June 2006. P. 9

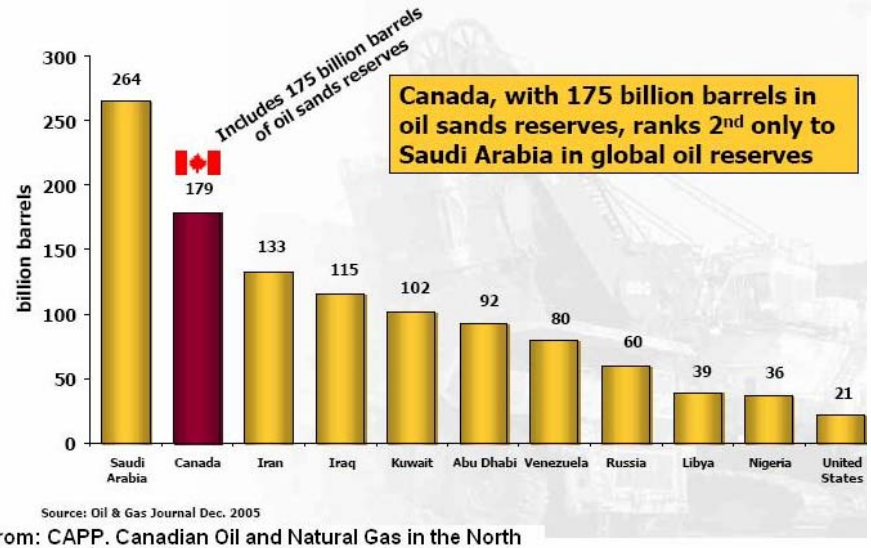
National Energy Board concluded that oil sands production will grow from 1.1 million b/d in 2005 to 3.0 million b/d in 2015
Canada's Oil Sands: Opportunities and Challenges to 2010 – An Update

U.S. and Canadian Markets for Crude Oil

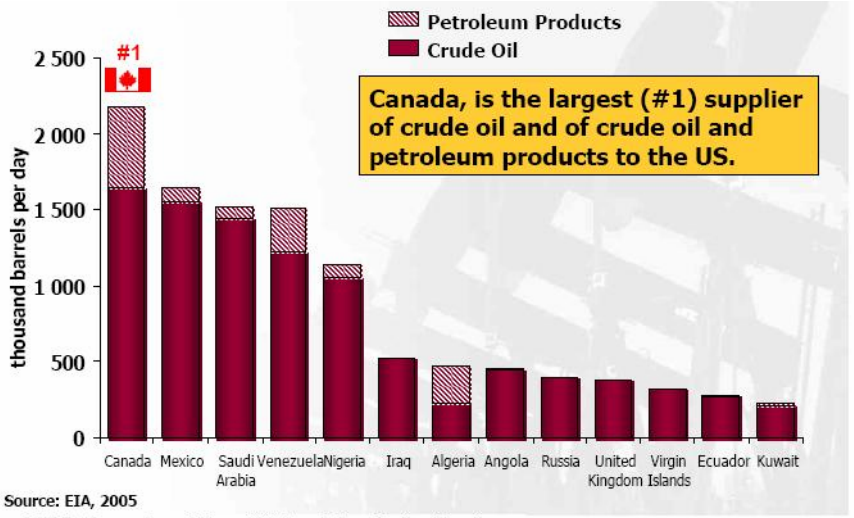


T Wise Purvin & Gertz June 2005

Global Crude Oil Reserves and US Imports (CAPP)

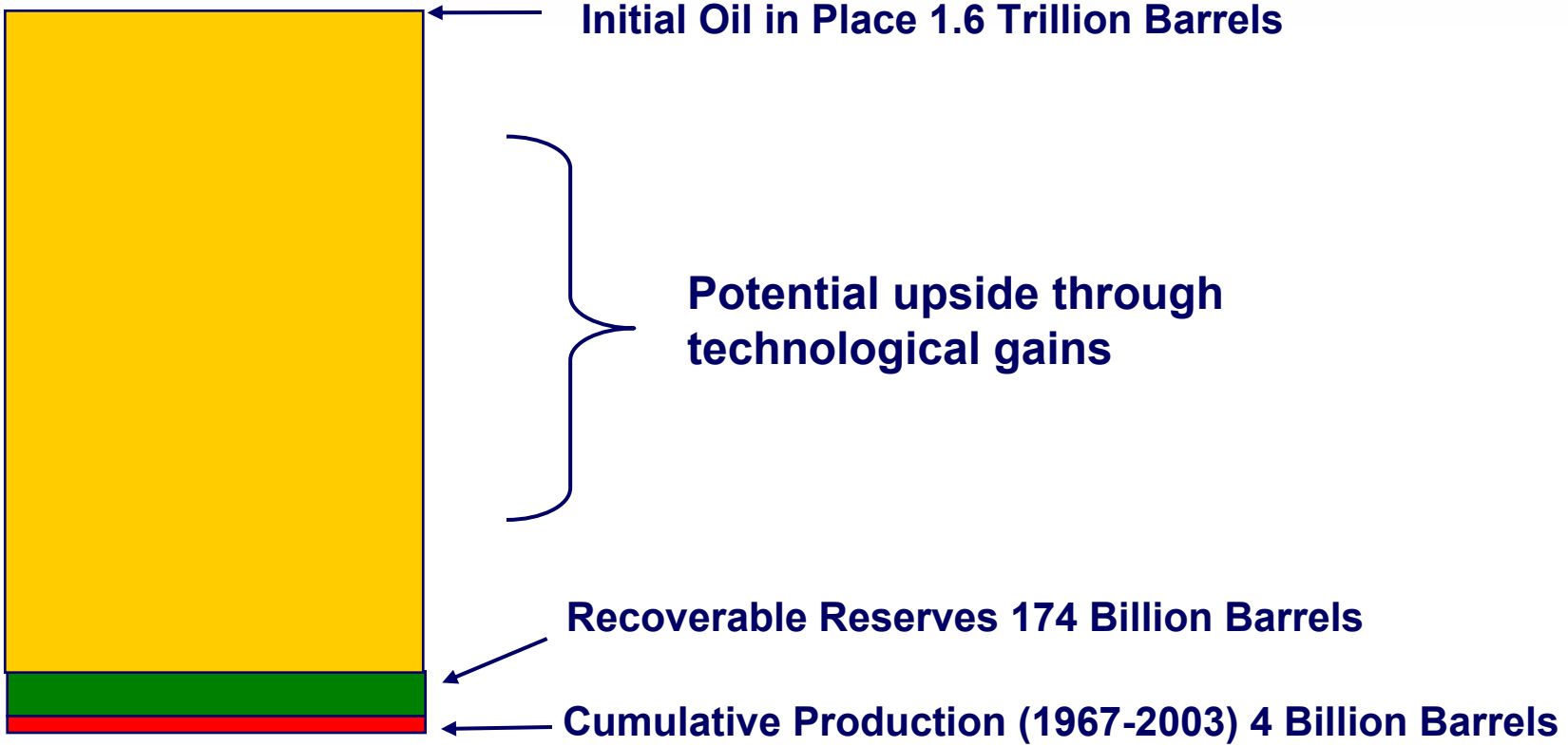


From: CAPP. Canadian Oil and Natural Gas in the North American Market. Washington DC, June 2006. P. 6



Slide from: CAPP. Canadian Oil and Natural Gas in the North American Market. June 2006. P. 4.

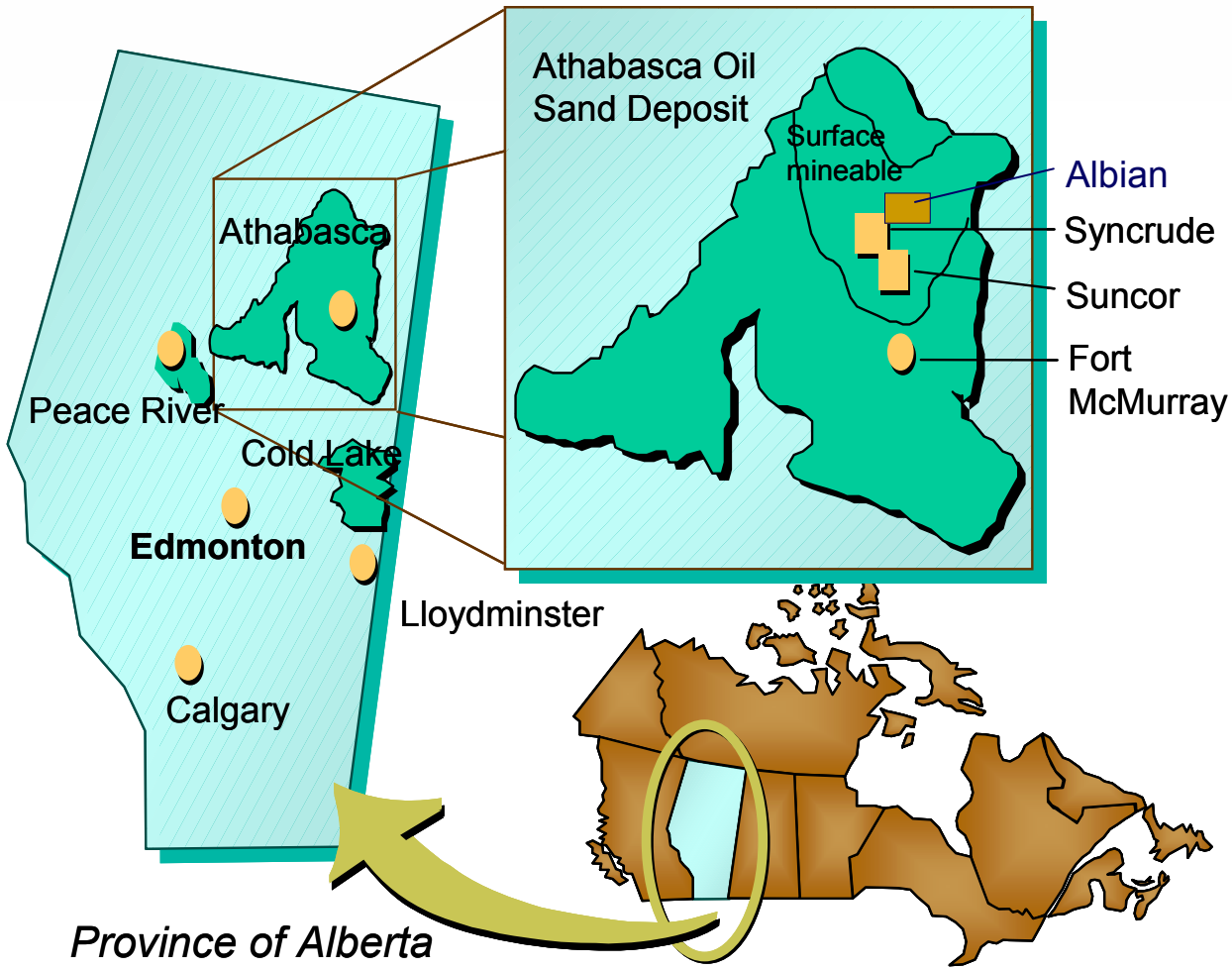
Canadian Oil Sands Potential



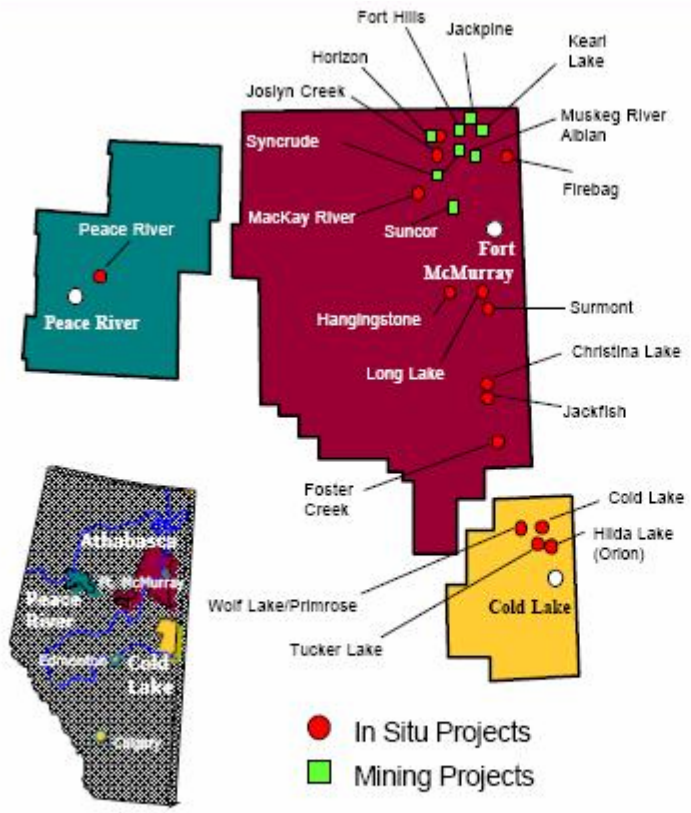
T Wise Purvin & Gertz June 2005

Oil Sands Deposits in Alberta

(Courtesy of Syncrude Canada Ltd.)



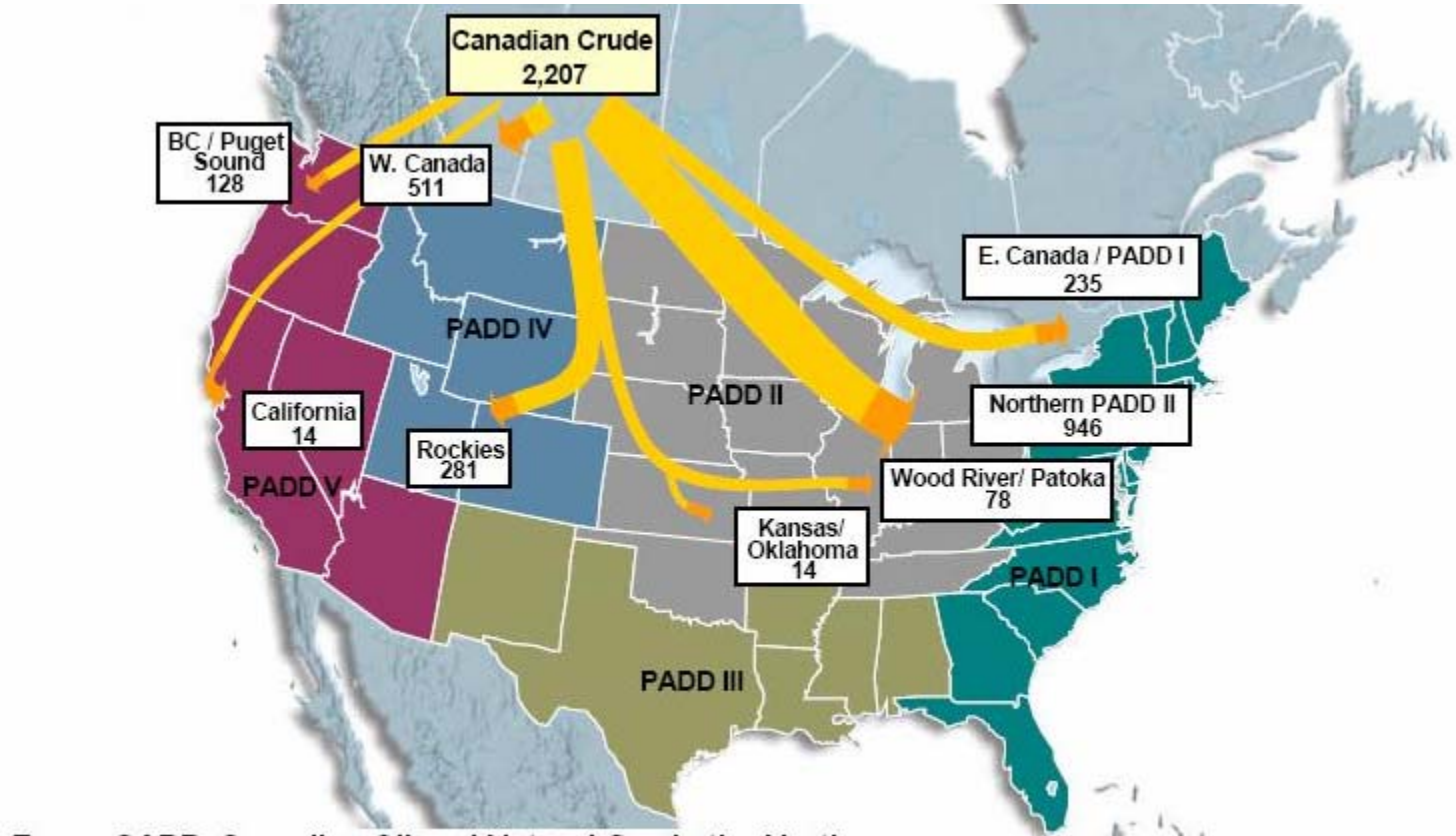
Oil Sands Projects



Athabasca – Mining		Barrels per day	
Operator	**Project**	**Initial**	**Potential**
Albian/Shell	Muskeg/Jackpine	150,000	500,000
Suncor	Base Plant	280,000	550,000
Syncrude	Base Plant	300,000	600,000
CNRL	Horizon (2008)	110,000	232,000
Imperial	Kearl (2010)	100,000	300,000
Petro-Canada	Fort Hills (2011)	50,000	190,000
Athabasca – In Situ Thermal			
JACOS	Hangingstone (pilot)	10,000	30,000
Suncor	Firebag	35,000	
ConocoPhillips	Surmont (2006)	16,000	110,000
Devon	Jackfish (2008)	35,000	70,000
Encana	Christina/Foster (2006)	30,000	400,000
Husky	Sunrise (2008)	50,000	200,000
OPTI/Nexen	Long Lake (2007)	70,000	140,000
Petro-Canada	MacKay River (2009)	24,000	60,000
Synenco	Northern Lights (2010)	50,000	100,000
Total E&P	Joslyn Creek (2006)	10,000	200,000
Cold Lake – In Situ Thermal			
Blackrock	Orion-Hilda Lake pilot	500	20,000
CNRL	Wolf Lake/Primrose	50,000	120,000
Imperial	Cold Lake	130,000	180,000
Husky	Tucker (2006)	18,000	35,000
Peace River – In Situ Thermal			
Shell	Peace River	12,000	100,000

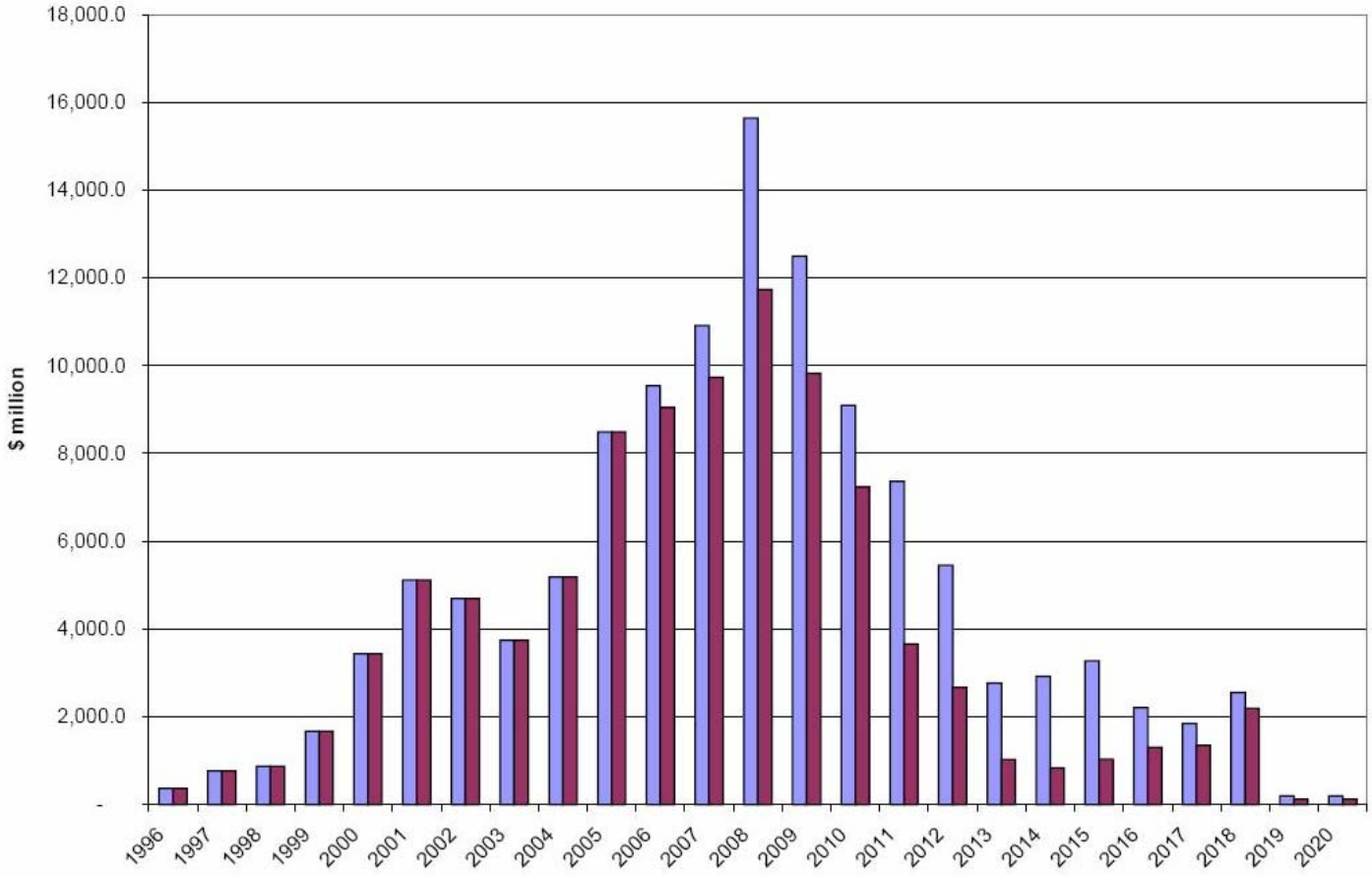
From: CAPP. Canadian Oil and Natural Gas in the North American Market. Washington DC, June 1006. P. 8

Western Canadian Crude Oil Markets 2005 (000 bpd)



From: CAPP. Canadian Oil and Natural Gas in the North American Market. Washington DC, June 1006. P. 12

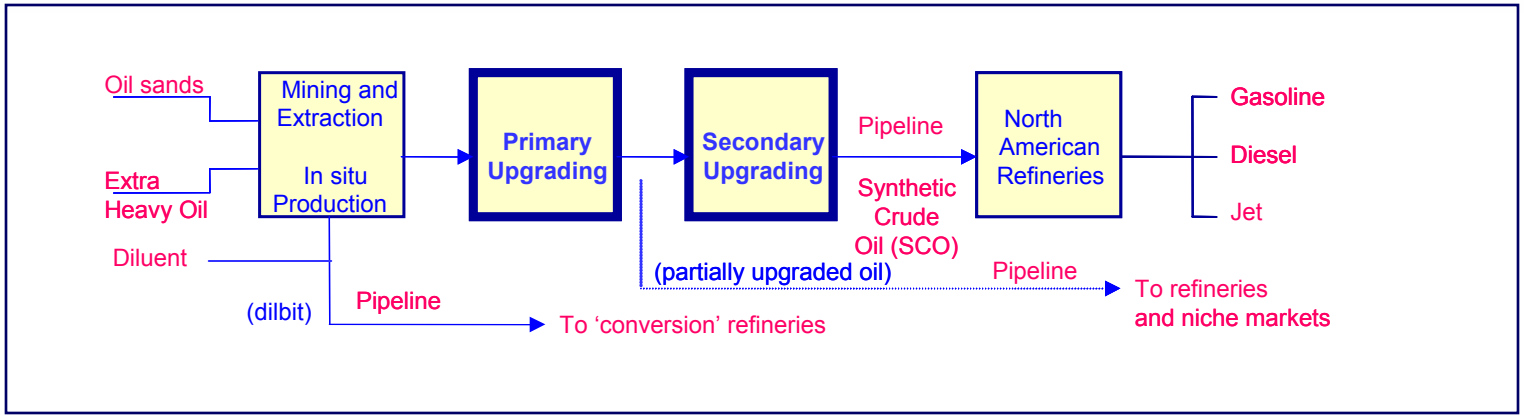
Oil Sands Industry Expenditure Forecast



From "Oil Sands Industry Update", Alberta Economic Development, June 2006, p.24

Upgrading Oil Sands Bitumen to Clean Fuels

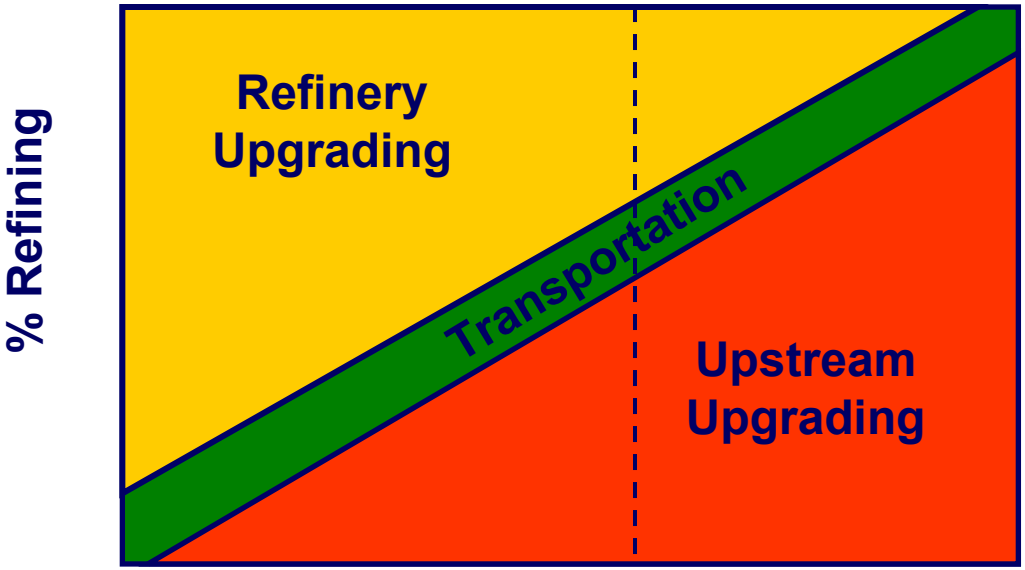
Processes and Markets

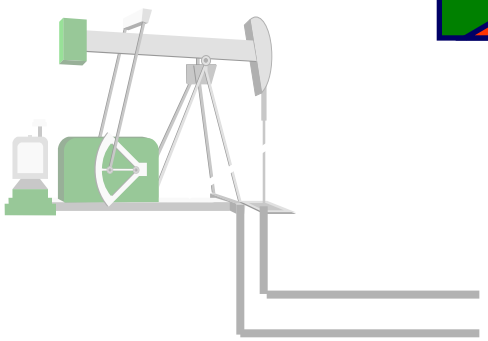


Product Quality (Chemistry)

Bitumen		SCO		Ultra-Clean Fuels
Hydrogen/carbon = 1:1 Aromatic High sulphur	→	Large diesel component Low sulphur Aromatic	→	Hydrogen/carbon = 2:1 No sulfur

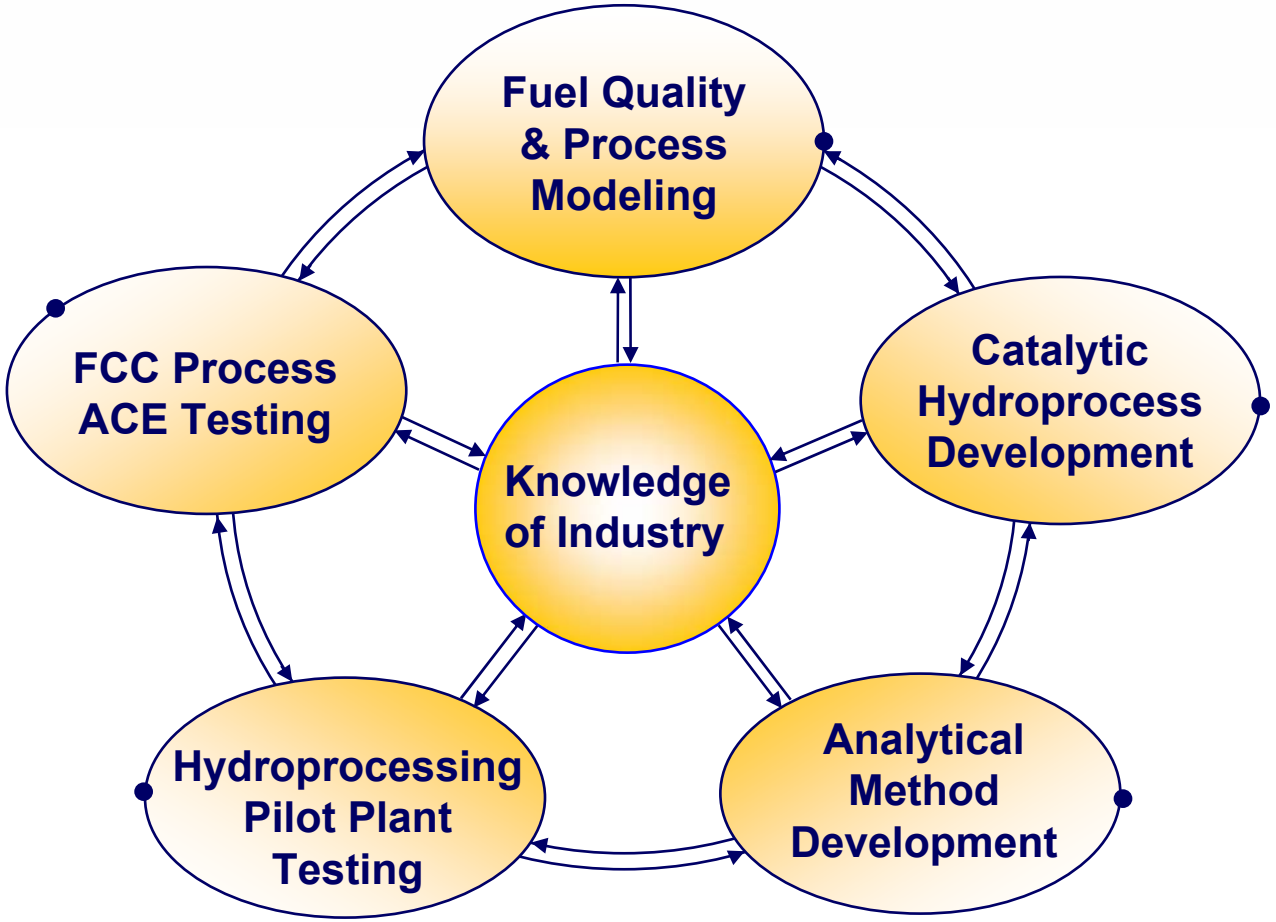
Upgrading, Transportation & Refining are Needed for the Clean Fuels Market to Utilize Alberta Bitumen





T Wise Purvin & Gertz June 2005

National Centre for Upgrading Technology Secondary Upgrading

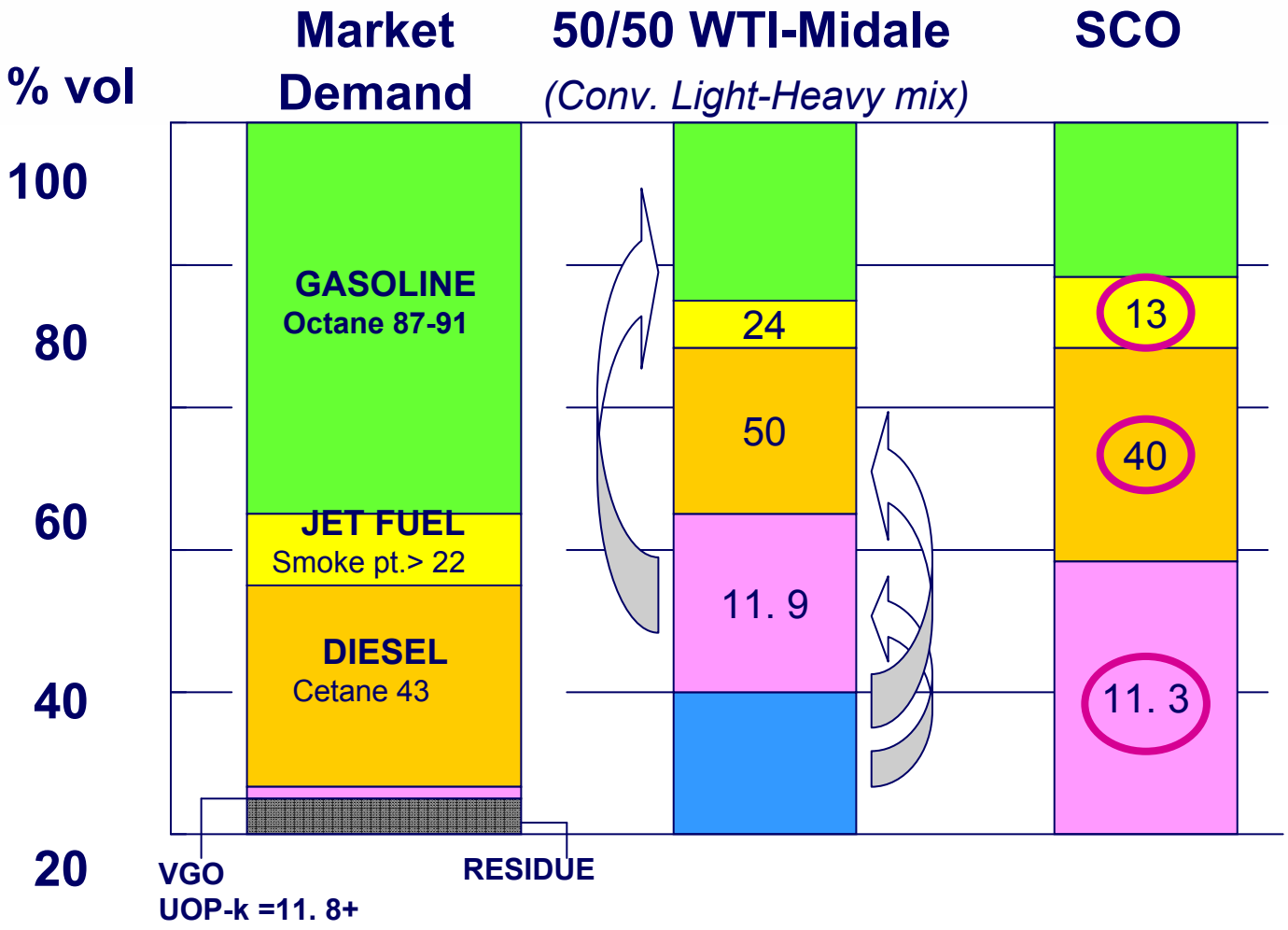


NCUT Product Modeling

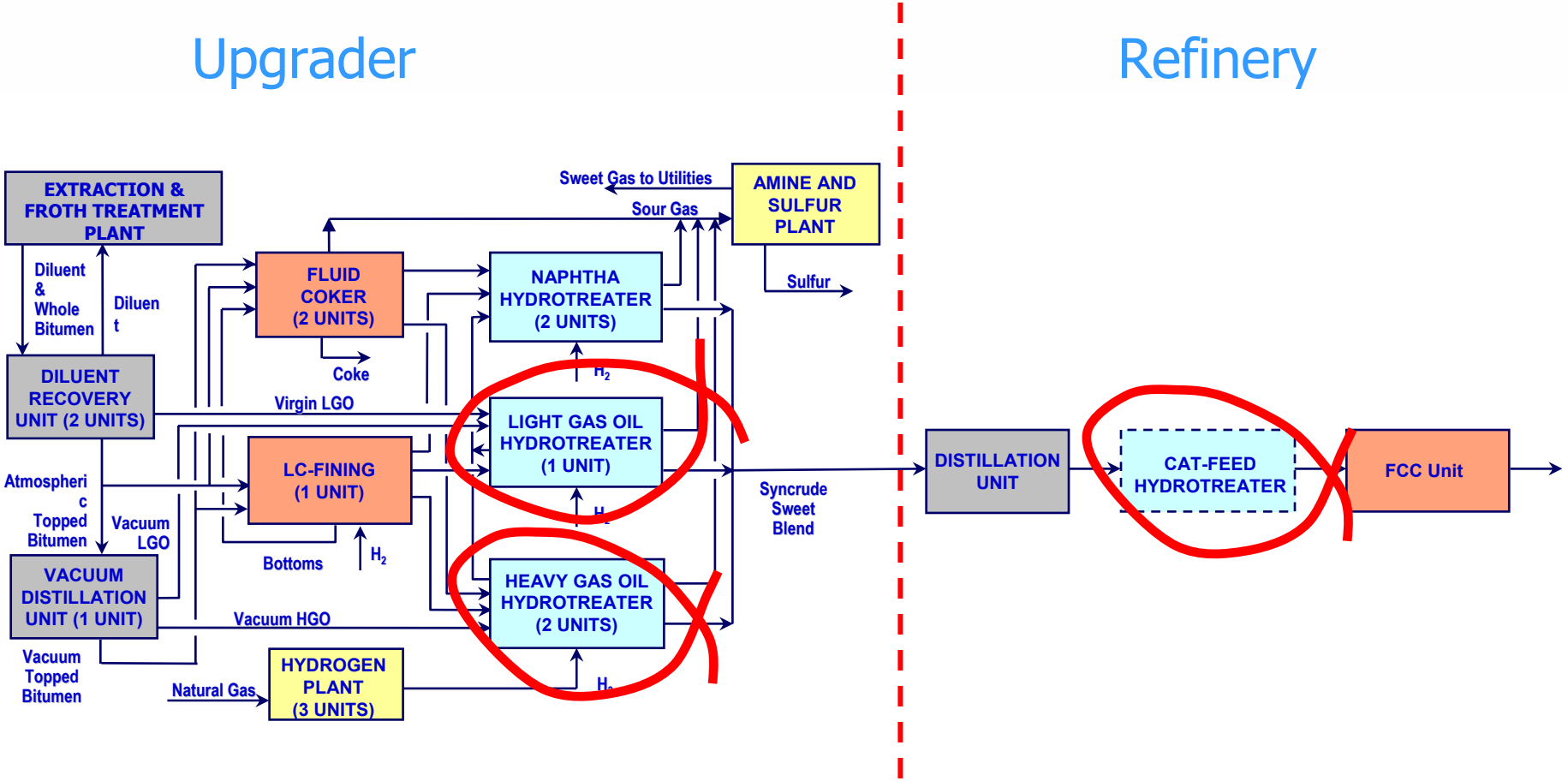
End BP	210	220	230	240	250	260
Saturates	4.84	6.86	7.22	8.56	7.62	8.14
Paraffins	1.00	1.18	1.58	1.65	2.19	1.09
Isoparaffins	1.00	0.86	1.58	1.13	2.19	0.45
n-Paraffins	0.00	0.32	0.00	0.52	0.00	0.64
Cycloparaffins	3.84	5.67	5.64	6.91	5.43	7.04
Monocycloparaffins	1.25	1.67	2.02	2.82	2.13	2.85
Dicycloparaffins	2.56	3.89	3.40	3.58	2.66	3.21
Polycycloparaffins	0.03	0.12	0.22	0.51	0.64	0.99
Aromatics	0.21	0.24	0.37	0.79	0.58	0.94
MonoAromatics	0.21	0.24	0.37	0.77	0.58	0.91
Alkylbenzenes	0.18	0.15	0.20	0.23	0.27	0.26
Benzocycloalkanes	0.04	0.09	0.17	0.53	0.31	0.65
Benzodicycloalkanes	0.00	0.00	0.00	0.00	0.00	0.01
Diaromatics				.01	0.00	0.03
Naphthalenes				.01	0.00	0.03
Biphenyls				.00	0.00	0.00
Naphthocycloalkanes				.00	0.00	0.00
Fluorenes	0.00	0.00	0.00	0.00	0.00	0.00
Triaromatics	0.00	0.00	0.00	0.00	0.00	0.00
Phenanthrenes	0.00	0.00	0.00	0.00	0.00	0.0
Phenanthrocyclolalkanes	0.00	0.00	0.00	0.00	0.00	0
Tetraaromatics	0.00	0.00	0.00	0.00	0.00	
Pyrenes	0.00	0.00	0.00	0.00	0.00	
Crysenes	0.00	0.00	0.00	0.00	0.00	
Aromatic Sulfur	0.00	0.00	0.00	0.01	0.00	
Benzothiophenes	0.00	0.00	0.00	0.01	0.00	
Dibenzothiophenes	0.00	0.00	0.00	0.00	0.00	
Olefins	0.00	0.00	0.00	0.00	0.00	0
C	0.618	0.236	0.340	0.347	0.483	0.5
H	0.093	0.033	0.044	0.049	0.049	0.06
S	0.000	0.000	0.000	0.000	0.000	0.000
N	0.000	0.000	0.000	0.000	0.000	0.000

LCO

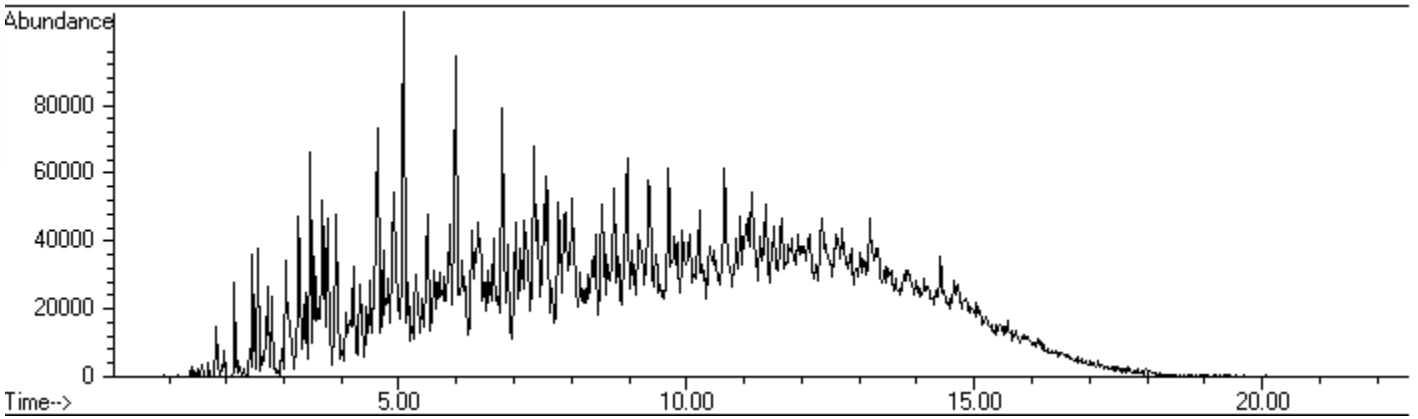
- Aniline point
- Cetane Number
- Ignition Quotient (IQT)
- Cloud Point
- Density (15.6°C)
- Flash Point
- Molecular Weight
- RI
- Pour Point
- Viscosity (40/80°C)


Market Demand
50/50 WTI-Midale
(Conv. Light-Heavy mix)
SCO
% vol
100
80
60
40
20
0
GASOLINE
Octane 87-91
JET FUEL
Smoke pt.> 22
DIESEL
Cetane 43
VGO
UOP-k =11. 8+
RESIDUE
24
50
11. 9
13
40
11. 3

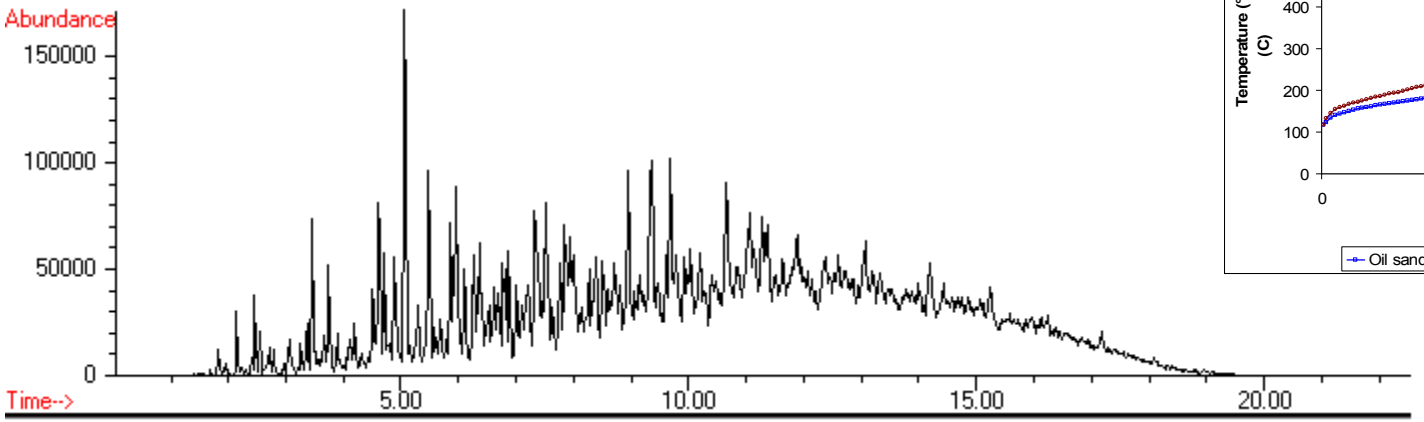
Where to attack the problem? @ Upgrading/Refining Interface



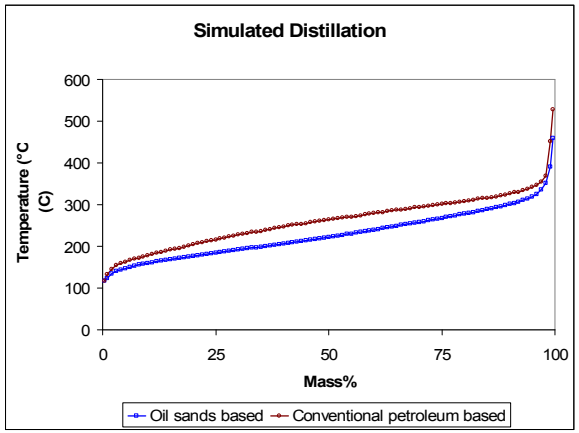
GC-FIMS Chromatograms of ULSD Blend Streams



Oil sands based



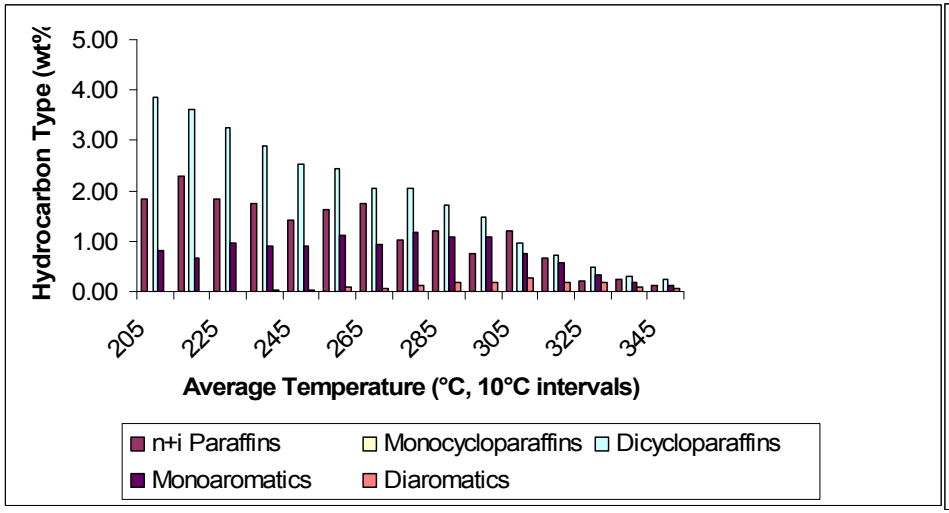
Conventional petroleum based



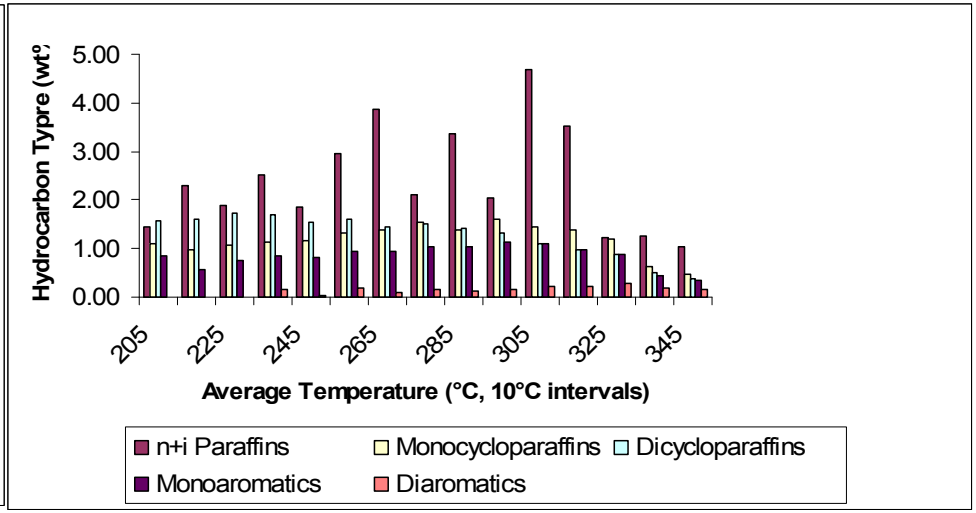
Tabular GC-FIMS Data (200°C+)

Boiling Range	210 - 220°C										
		Oil sands based					**Conventional petroleum based**				
HC Type	**Z No**	**C11**	**C12**	**C13**	**C14**	**Total**	**C11**	**C12**	**C13**	**C14**	**Total**
Saturates		**0.16**	**5.75**	**3.59**	**0.04**	**9.54**	**0.13**	**2.96**	**1.76**	**0.15**	**5.00**
n+i Paraffins		**0.00**	**0.66**	**1.63**	**0.01**	**2.29**	**0.00**	**1.03**	**1.12**	**0.14**	**2.30**
isoparaffins	2	0.00	0.01	1.63	0.01	1.64	0.00	0.03	1.12	0.14	1.29
n-Paraffins	2	0.00	0.65	0.00	0.00	0.65	0.00	1.01	0.00	0.00	1.01
Cycloparaffins		**0.16**	**5.09**	**1.97**	**0.03**	**7.25**	**0.13**	**1.93**	**0.63**	**0.01**	**2.71**
Monocycloparaffins	0	0.00	2.02	1.09	0.03	3.14	0.00	0.60	0.36	0.01	0.97
Dicycloparaffins	-2	0.12	2.80	0.70	0.00	3.61	0.11	1.25	0.23	0.00	1.59
Polycycloparaffins	-4	0.04	0.28	0.18	0.00	0.50	0.02	0.08	0.04	0.00	0.15
Aromatics		**0.37**	**0.28**	**0.03**	**0.00**	**0.68**	**0.32**	**0.22**	**0.02**	**0.00**	**0.56**
MonoAromatics		**0.37**	**0.28**	**0.03**	**0.00**	**0.68**	**0.32**	**0.21**	**0.02**	**0.00**	**0.55**
Alkylbenzenes	-6	0.14	0.21	0.02	0.00	0.36	0.13	0.15	0.01	0.00	0.29
Benzocycloalkanes	-8	0.23	0.06	0.02	0.00	0.31	0.19	0.06	0.01	0.00	0.26
Benzodicycloalkanes	-10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diaromatics		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.01**
Naphthalenes	-12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Biphenyls	-14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphthocycloalkanes	-14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fluorenes	-16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Triaromatics		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Phenanthrenes	-18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phenanthrocyclolalkanes	-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tetraaromatics		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Pyrenes	-22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crysenes	-24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					Total	**10.22**				**Total**	**5.57**

GC-FIMS Distribution by Boiling Point

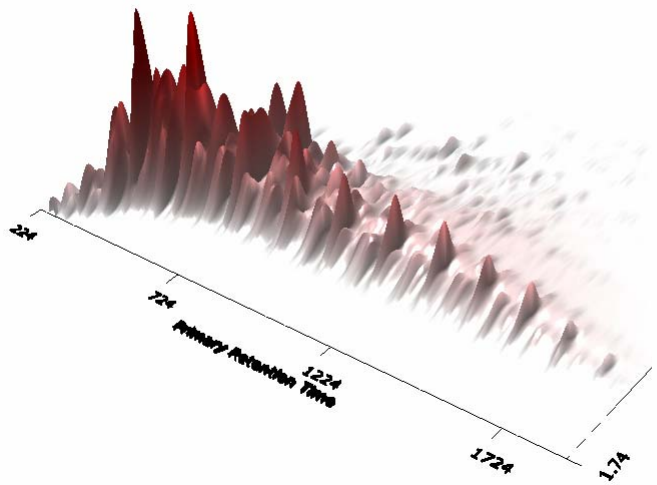


Oil sands based

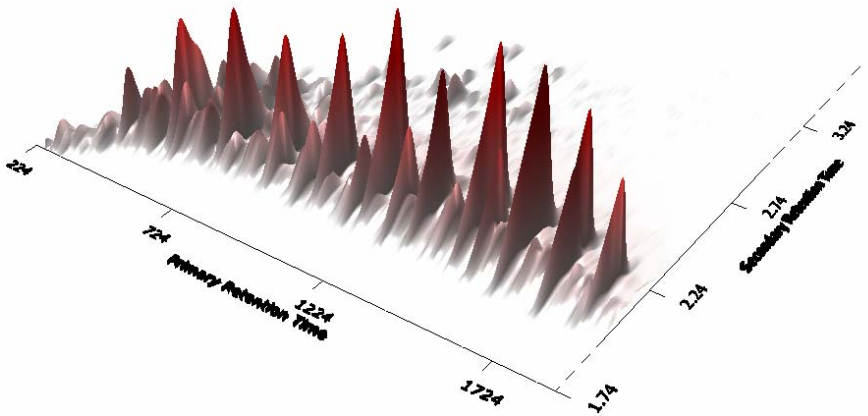


Conventional petroleum based

2D-GC Comparison (FID)

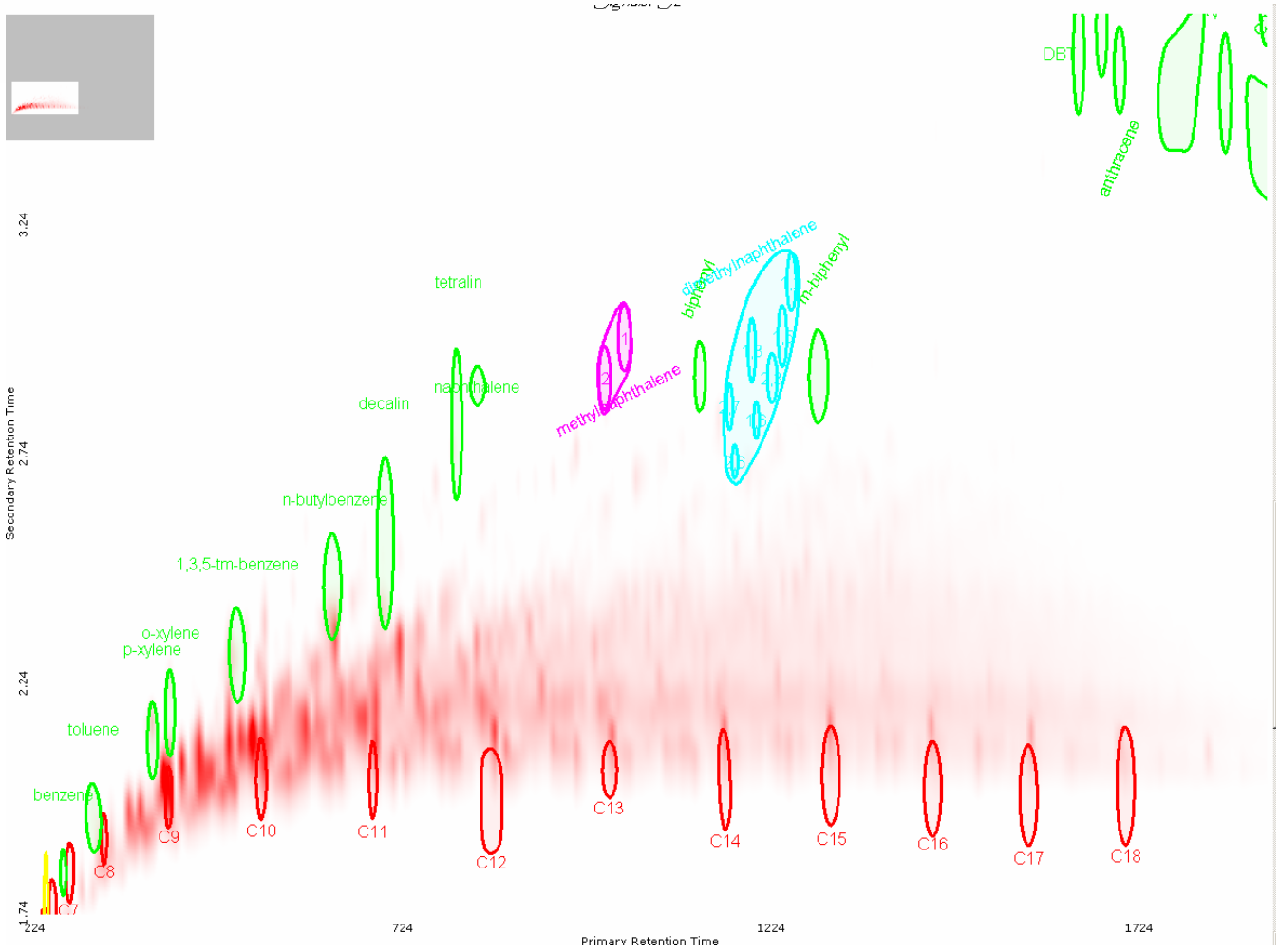


Oil sands based



Conventional petroleum based

Two Dimensional Gas Chromatography – FID Signal



Oil Sands Development

- Transportation fuel production from Alberta's oil sands is growing at a rapid pace
- Oil sands could be the single largest petroleum supply to the U.S.A.
- The value chain in oil sands is technology intensive
- A number of technology challenges and opportunities to ensure responsible growth have been mapped out
- Capital investment in oil sands production and upgrading is substantial
- Security and Prosperity Partnership of North America – Oil Sands Initiative

Knowledge Gaps

- Effect of diesel fuel chemistry on combustion, engine emissions, lubricity, and after treatment technologies for future engines
- Effect of diesel fuel chemistry and blends (conventional crude derived diesel fuel, oil sands, bio-fuels and Fischer Tropsch fuels) on tomorrow's engines
- Could low temperature combustion engine technology change fuel requirements?
- Oil Sands Chemistry and Engine Emissions Roadmap Workshop, June 2005, Edmonton, Alberta, Canada

Where do we go from here?

- Chemistry models and combustion models need to work together (i.e. chemical descriptors used to characterize diesel fuel for processing research need to be useful for combustion models and engine research)
- Standard fuels, including oil sands components, need to be evaluated in several engine R&D programs to better correlate fuel chemistry to engine emissions (both today's and tomorrow's engines)
- National Centre for Upgrading Technology has established working relationships with US researchers (PNNL and ORNL) to understand how future engine technologies may affect oil sands processing and vice versa
- NCUT also has working relationship with combustion researchers at National Research Council Canada

Future Fuels for Future Engines

Processing

- ongoing research, development and demonstration activity
- Producer - upgrader - refiner interface
- new production, upgrading and refining technologies that deliver higher quality products
- variety of bitumen-derived products but Heavy Gas Oil is critical
- FCC – conversion capacity
- process models provide guidance and detailed analysis would help

Engines and Emissions

- passenger vehicle and on-road and off-road diesel engines
- government policy and vehicle/engine regulations and harmonization
- new vehicle/engine technology standards
- current/future fuels in current/future engines
- analytical research and composition - emissions models

Hydrocarbon and Fuel Quality

- hydrocarbon stream and diesel fuel on-going activity
- government policy, fuel regulations and harmonization
- fuel standards (CGSB & ASTM, EPA & CEPA)
- stability, compatibility, cetane number, lubricity, additives
- analytical research & product quality models

Additional Sources

- There is some useful information on oil sands in the web sites below:

- http://www.energy.gov.ab.ca
- www.ptac.org
- http://www.acr-alberta.com/
- http://www.choa.ab.ca/
- http://www.capp.ca/
- http://www.ccqta.com/
- http://www.neb.gc.ca/whatsnew/index_e.htm