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Centre for Global Energy Studies

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"Difficult Oil"

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Outline

- Introduction-definitions
- Resources
- Production
- Outlook
- Why/why not invest
- Market and other issues
- Summary / Propositions for discussion

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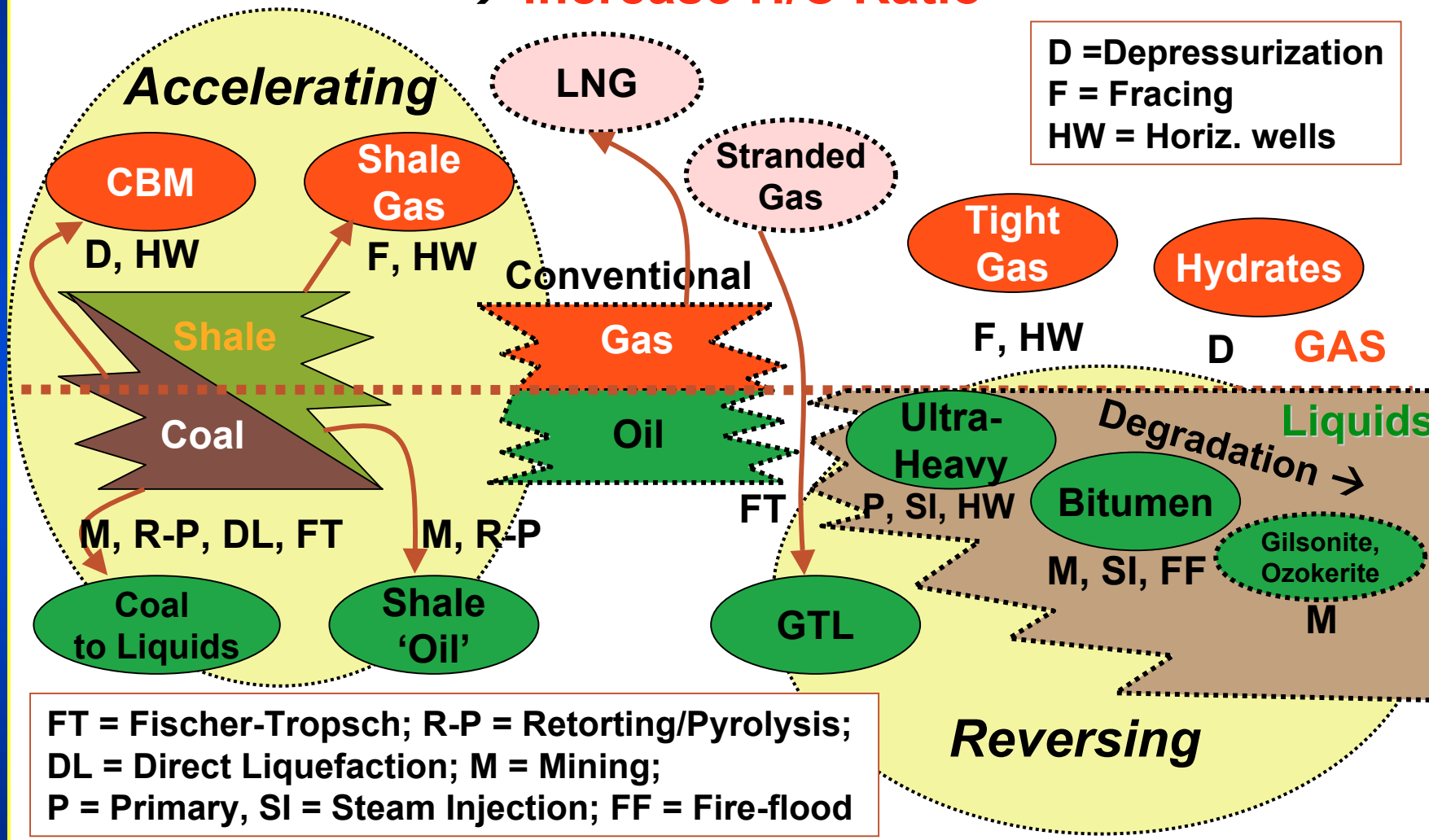
Unconventional Oil & Gas: A Conceptual Framework

Accelerating or *Reversing* geological processes

→ increase H/C Ratio

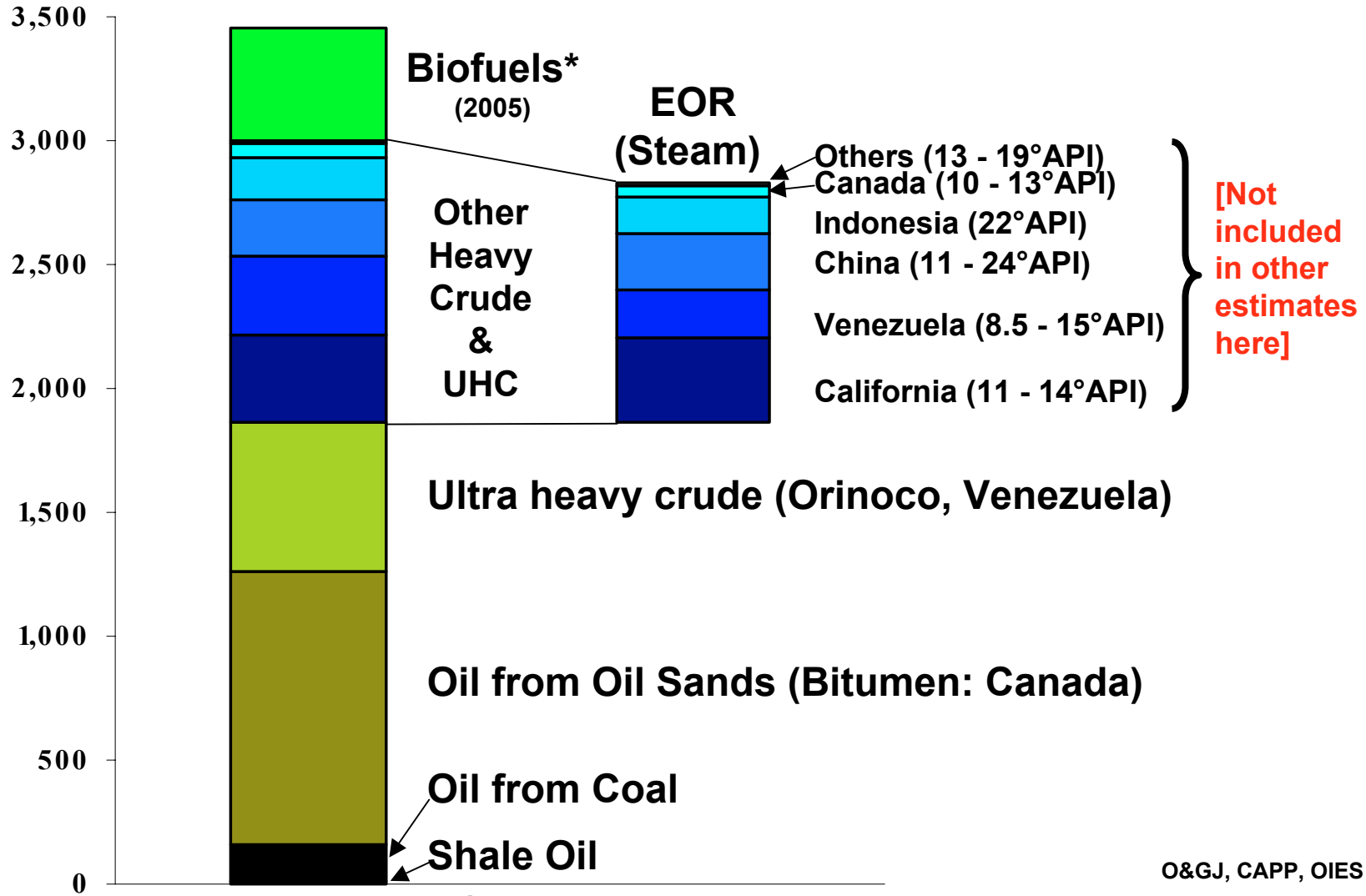


D =Depressurization
F = Fracing
HW = Horiz. wells

FT = Fischer-Tropsch; R-P = Retorting/Pyrolysis;
DL = Direct Liquefaction; M = Mining;
P = Primary, SI = Steam Injection; FF = Fire-flood

Bio-Ethanol ← Sugar cane, maize, wheat, sugar beet, cellulose…
Bio-diesel ← Vegetable oils, Jatropha bean, oil nuts…

Estimated Production of Unconventional Liquids (04)



O&GJ, CAPP, OIES

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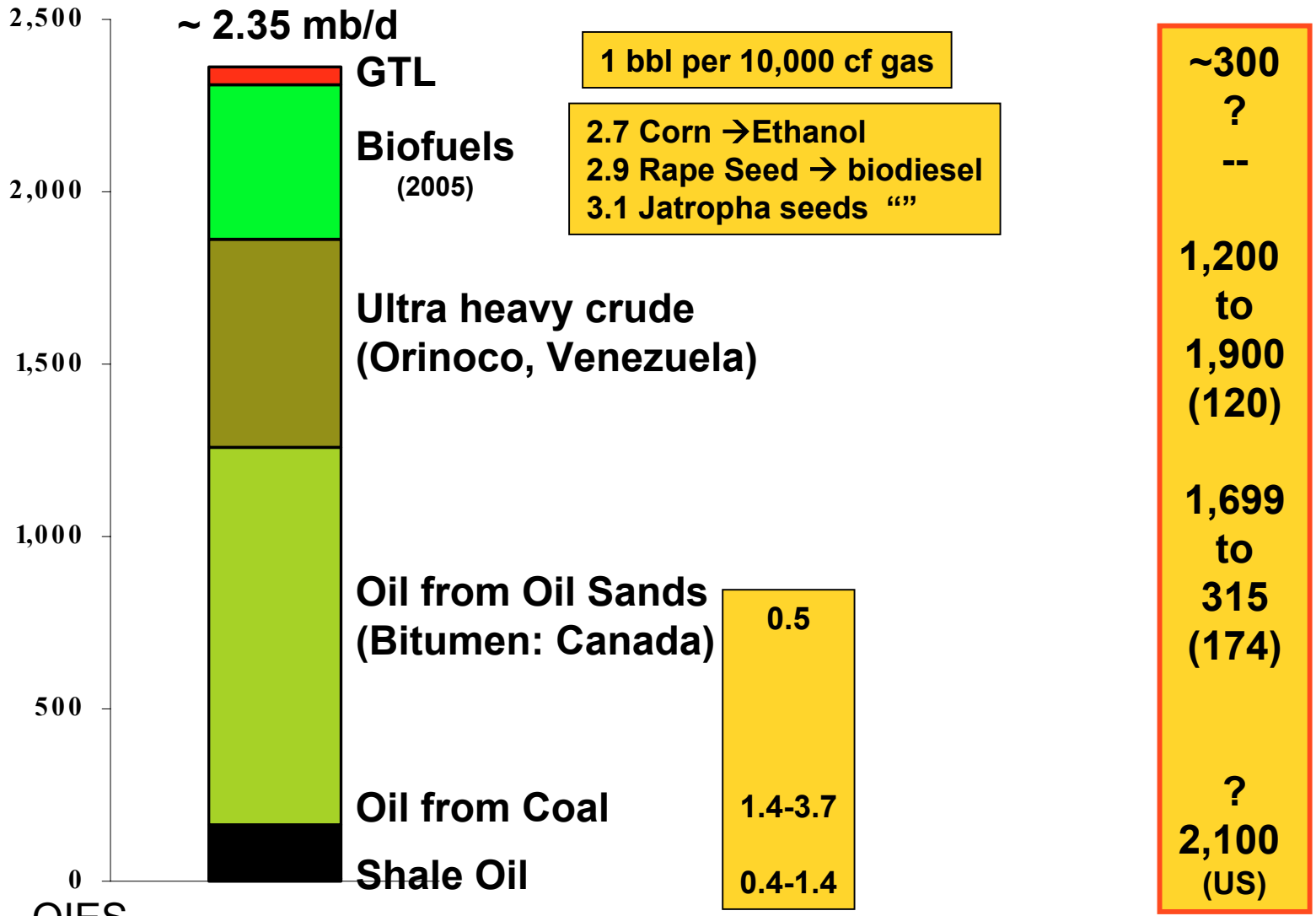
Difficult Oil



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Oil from Coal

- Liquid by-product of coke production (1840's)
- Original feedstock (aromatics) for petrochemical industry
- UK and Germany (WWII), and Apartheid South Africa
- Direct and Indirect processes (> 30 schemes developed)
- China looking at large development (> 1 mb/d)
- Environmental penalties (7 – 10X CO_2 vs conv crude)
- Energy penalties (55% to 70% energy conversion)
- Potential long term bridge to Hydrogen future with sequestration of Carbon but significant replacement of conventional crude would require massive increase in coal production

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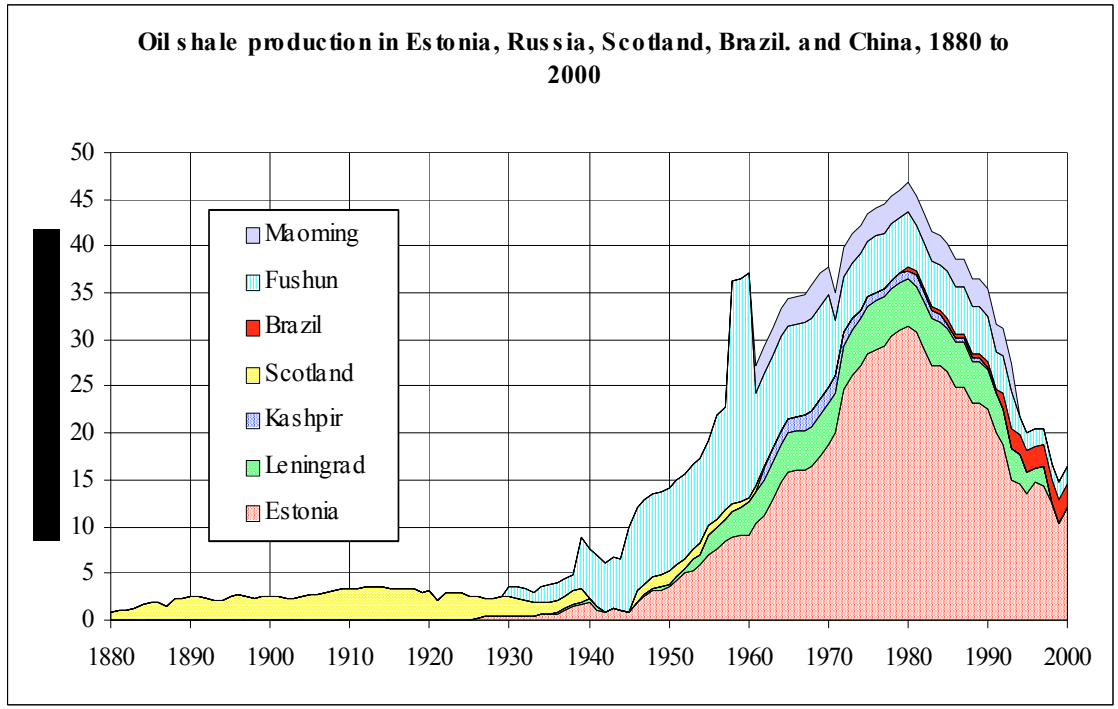
Oil from Shale

- **Very long history**
- **Massive resource**
- **Requires a lot of energy and water**
- **Wastes / Tailings**
- **Brazil project**
- **Green River Shales; Largest resource in the world in one of the driest parts of the US: Shell in situ electric heating pilot.**
- **Has always been 'tomorrow's energy source'.**
- **New US Energy Policy Act (Sec 369) promotes 're-launch'**



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Biofuels

- Mostly Ethanol (Brazil, USA); EU favors Biodiesel
- > 30 countries have launched Biofuels programs.
- Mandates and targets in US and EU
- EU farmers oppose cellulose-based Biofuels
- US promoters oppose imported sugar-based ethanol

- Essentially an agro-business / rural subsidy business
- Great political appeal (jobs, 'self-supply', environment)
- Debate whether net environmental and energy benefits
- Market problems with blending
- Farmers' opportunity to integrate downstream
- But volumes & trade are growing very fast

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GTL: What & Why?

-70-year old technology (Fischer-Tropsch), with new innovations in design and catalysts → very high quality suite of products (Diesel, Paraffinic Naphtha → Petrochemicals, plus Lubricants and Waxes)

$$CH_4 + O_2 + H_2O \rightarrow CO + H_2 \xrightarrow{(Fe, Co)} --n(CH_2)-- + H_20$$

- **Monetize 'stranded' gas resources**
- **Diversification (for producer & consumer)**
- **Environmental (X flaring & product specs)**
- **Corporate**
  - **Monetize R&D and I.P. investments**
  - **Materiality & baseload production**
  - **Reserves booking of feedstock gas (boe) and Associated Liquids (C_{5+})**
  - **Product specs compliance**
  - **Market dominance in specialty products**

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GTL Project List is long…

Project/Company/Country	Existing / Under construction (b/d)	Announced or Under Study (b/d) start year
Mossgas, PetroSA, South Africa	23,000	
Bintulu, Shell, Malaysia	14,700	
Pilots (9)	2,360	
ORYX, Sasol/QP, Qatar	34,000 (06)	
Sasol/QP, Qatar		65,000 (09)
Shell/QP, Qatar 'Pearl'		140,000* (2 X 70,000) (09, 11)
Chevron/Sasol/QP		130,000 (10+)
Exxon Mobil/QP, Qatar		150,000* (2 X 75,000) (11)
Conoco/Phillips/QP, Qatar		160,000* (2 X 80,000)
Marathon/QP, Qatar		120,000* (2X 60,000
Shell/NPC, Iran		75,000
Statoil/NPC, Iran		20,000*
Sasol/NIOC, Iran		140,000 (2 X 70,000)
Shell, Pertamina, Indonesia		75,000
Sasol/Chevron/NNPC, Nigeria	34,000 (06/07)	
Sasol/Chevron, Australia		34,000 – 200,000
EGPC/Shell, Egypt		75,000
Rentech, Bolivia		10,000*
Brazil-Syntroleum/Petrobras,		?
Reema Int/Syntroleum, Trinidad		10,000
PDVSA/Sasol		34,000
Sasol/PetroTrin, Trinidad		30,000
Gazprom/Yukos/Syntroleum		120,000 (12 X 10,000)

These projects =1,465 kb/d
Others identify >1,900 kb/d

* Reported FEED

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GTL Slowing down?

- Qatar announces slow-down in development: "reservoir"?, 'overheat'? or opportunity cost versus LNG?
- Countries with large reserves re-assessing LNG prospects given natural gas supply squeeze in North America
- Countries with small 'stranded' gas reserves/small fields still candidates for GTL (Trinidad?); want industrial diversification built on other, existing gas infrastructure/industry
- EPC supply, skills; specialty steel 'shortage'; large vessel suppliers very constrained
- COSTS are the key challenge for all GTL schemes. Not the time to assign these projects to the 'D-Team' → reputation risk;
- Banks prefer LNG: market expanding: no major potential surprises.
- GTL scale-up issues.

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GTL products Market

- Existing infrastructure/vehicle stock
- Diesel: high quality (S, Cetane, PM, HCs, CO), anticipates new specs—marketing tool
- Naphtha → good ethylene feedstock
- Kerosene: better to reduce output
- Specialty lubes and waxes face potential 'over-supply'. Operators must either discount, blend with conventional lube stocks or crack to shift output to lighter grades.
- 'Degrading' of ultra-high quality products
- Remember: it's transport service (CNG?)

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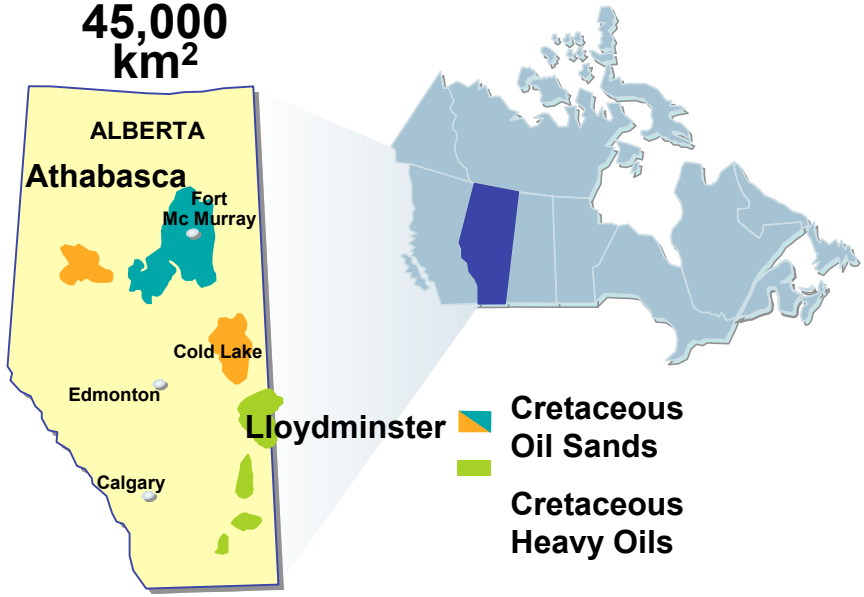
Ultra-Heavy Crude (Orinoco)
&
Bitumen (Athabasca Oil Sands)

54,000 km²

45,000 km²



Extra Heavy Oil in Place
1,360 Gbbls
Recoverable 120 Gbbls
(PDVSA)

Initial Bitumen in Place
1,699 Gbbls
Remaining Established 174 Gbbls
Ultimate Potential Recoverable
315 Gbbls
(AEUB, 2005)

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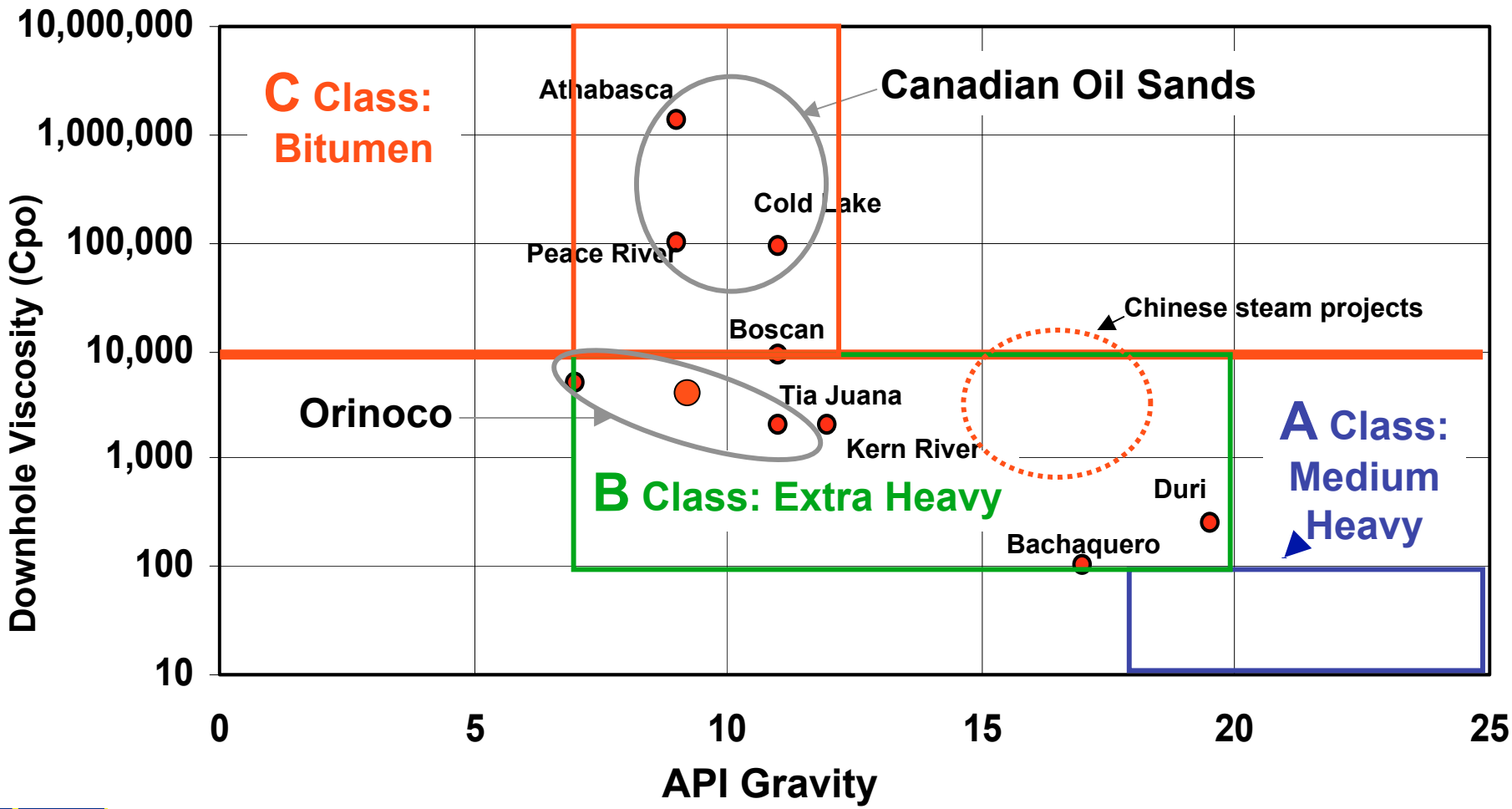
Heavy Oil Categories



After Kupcic, 2003

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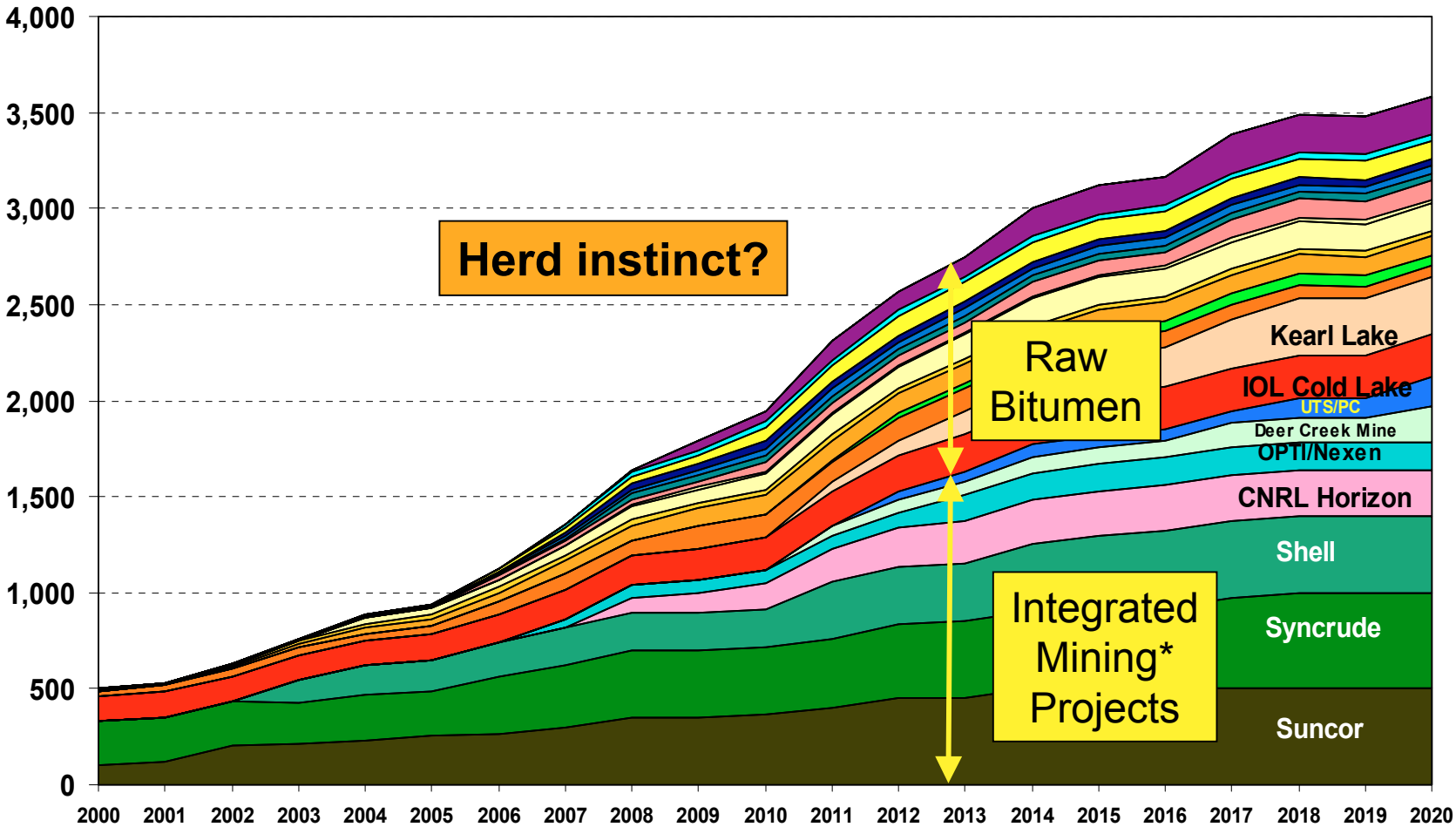
Alberta Oil Sands Projected Supply

1000 b/d

Estimated (risked) output adjusted from announced schedules



* Except OPTI/Nexen, which uses SAGD integrated with upgrader

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Source: OIES

Reasons firms give for investing in Oil Sands

- No or little geologic risk; materiality
- Long term predictable growth versus conventional decline
- Technology up-side:
  - Can unlock value through technology-driven cost reductions and increased reserves.
- With high % WI: can control pace.
- Practice makes perfect— once in it, keep doing it, but do it better.
- Lower risk profile, good for valuations
  - Manufacturing or 'annuity' profile (repeatable)
  - Balances conventional E&P profile
  - Balances offshore/foreign, riskier ventures
  - Less single event risk
  - Less cash flow volatility
  - Financial & equity markets like it
- Economics are robust:
  - Netbacks high; low F&D, long RLI
  - Amortize costs over large reserves
  - Minimal sustaining capital
  - Attractive fiscal regime, promotes expansion
  - IRR>industry WACC @ 9%

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But not all 'rosy' picture

- Project execution: large-scale, simultaneous projects in an northern environment (logistics, materials, equipment and skilled manpower) → major cost overruns
- High CAPEX projects limit scope for investments elsewhere
- Operational Risks: asset reliability in northern environment
- Natural gas supply (steam, power & hydrogen) unsustainable
- Markets: market saturation (need coking for Heavy Sour & cracking capacity for SCO); supply upsets, new market access
- Environmental issues and performance (CO_2 vs Recovery)
- 'Rent debate' starting (again)
- Financing: Business cycle; interest and exchange rates; SEC

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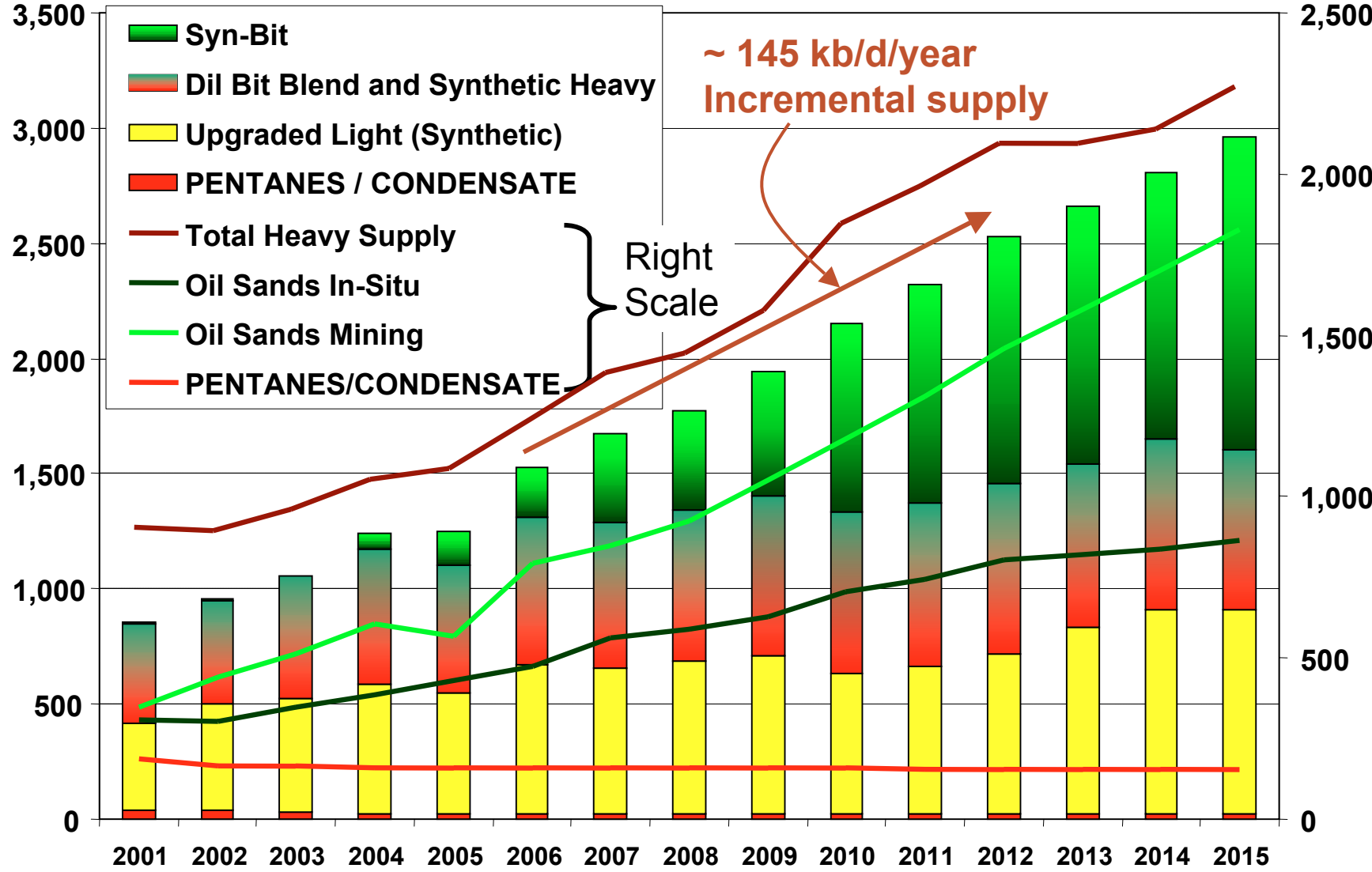
Oil Sands Production & Supply

2.5 mb/d — **Total Canadian Production (ex NGLs)** — **~ 4 mb/d**



Source: AEUB, CAPP, OIES

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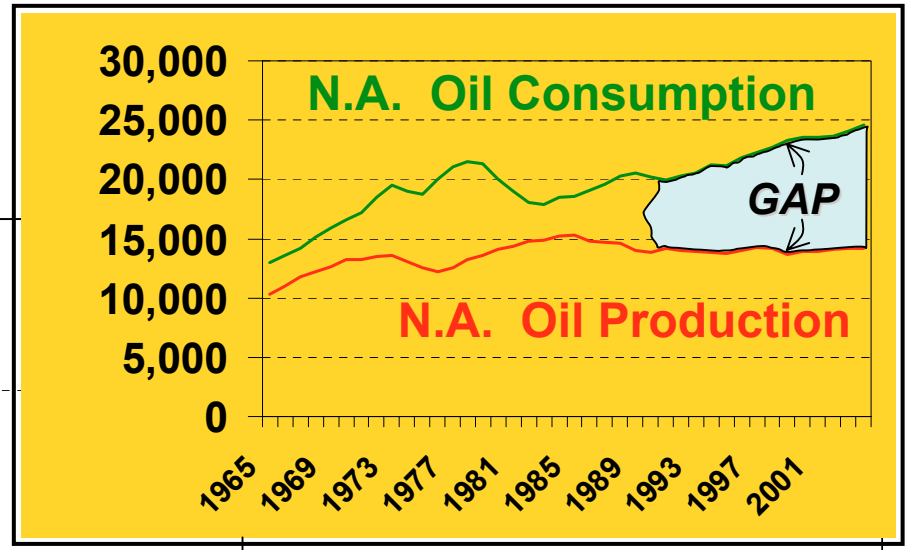
Oil Sands will be hard-pressed to fill Growing North American Supply – Demand Gap



1,000 b/d

Annual change in gap (BP)

Avg 1990 - 2004

US DOE/EIA 2005 Outlook
Projected N.A. Gap

Projected (OIES)

Annual Oil Sands Supply Additions (CAPP)

1,700
1,200
700
200
-300
-800

1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

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Source: OIES, BP (2005), CAPP, US DOE/EIA

Technology Challenges & Options

Natural Gas, Water Use, Emissions & Diluent

Mining (90% recovery already)

- At-face mobile, continuous mining & extraction
- Improve energy efficiency in water separation
- Tailings, water use, land recovery, resource conservation

Upgrading

- Better quality SCO
- Field upgrading to improve bitumen quality
- Reduce upstream CO2 emissions (15 to 30% of Life Cycle Emissions)

In Situ (40 – 70% recovery)

- Steam fuel (bitumen, asphaltenes, coal, POX …nuclear?)
- Reduce Steam Oil Ratio; improve water re-cycle, reduce use.
- Better down hole pumps
- Thief Zones; reservoir modelling and monitoring
- In situ partial upgrading (THAI™, VAPEX, catalysts, …microbes?)

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Difficult Oil: Projects

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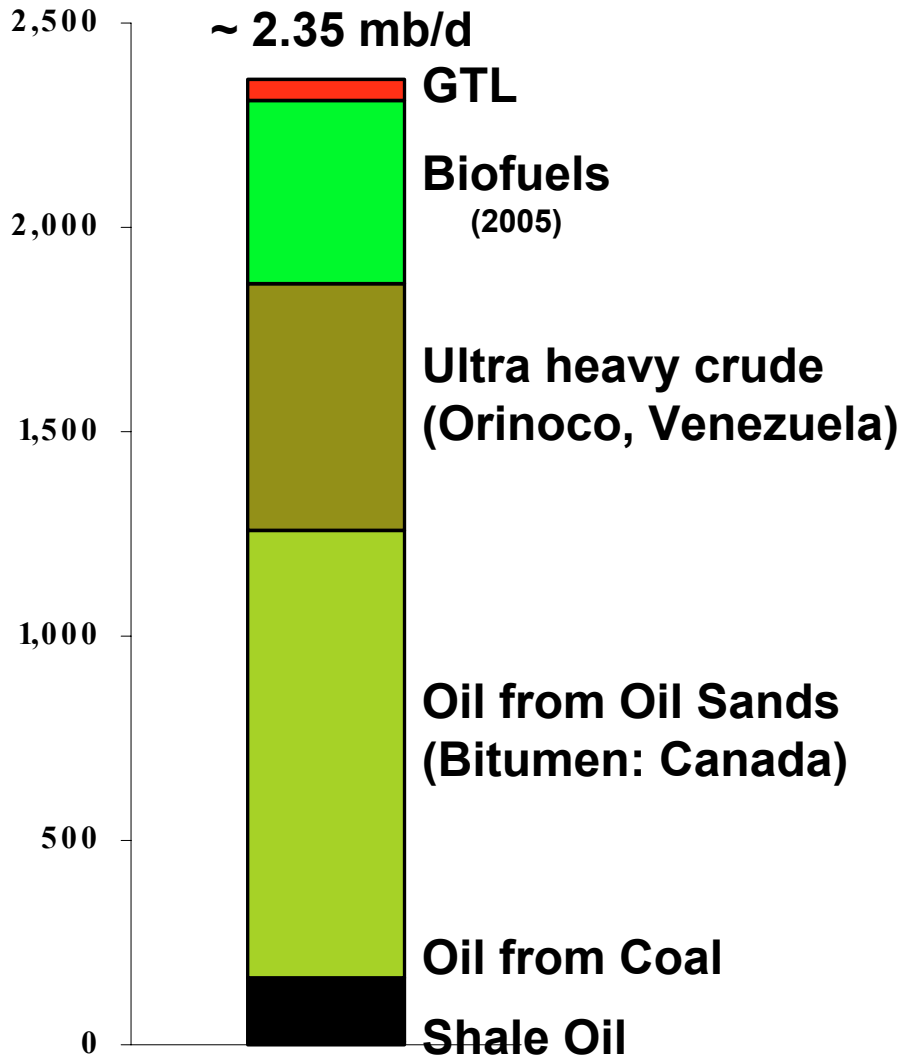
Production



Current & Proposed Projects

GTL	1.9
Biofuels (2005)	0.7 * *Gasoline Equivalent
Ultra heavy crude (Orinoco, Venezuela)	2.1
Oil from Oil Sands (Bitumen: Canada)	4.1
Oil from Coal	1.35
Shale Oil	
TOTAL ~ 10.15 mb/d	

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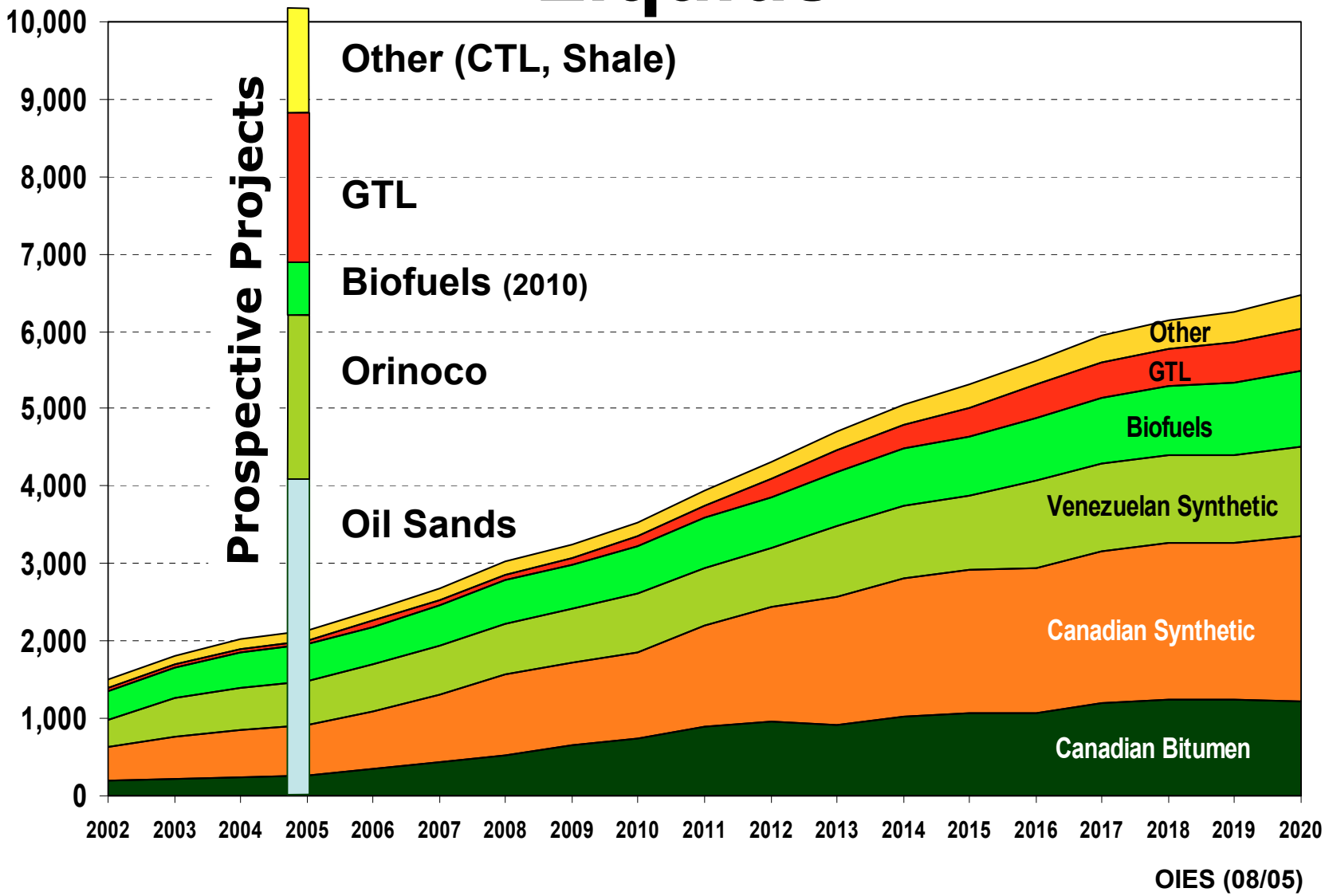
Outlook for Unconventional Liquids



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Estimated CAPEX ($000/b/d)

• Ethanol:	35 – 56*
Biodiesel:	13 – 15*
• GTL	25+ (target 20)
• Ultra heavy crude**	27 – 30
• Oil Sands**	30 – 40
• Coal to Liquids	40+?
• Oil from shale	?

* Plant only, gasoline equivalent (from recently announced plants Australia, EU, USA)

** For integrated project yielding fully upgraded synthetic crude

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Unconventional Oil: Some Propositions

- Supply will grow—especially from oil sands and Biofuels; GTL will slow; USA political push for shale & coal, but…?
- Orinoco: most economic, least discussed, likely to slow down until perceived political risk reduced
- Upgrading of heavy crudes and bitumen will increase at source to capture value (Alberta, Brazil, Saudi Arabia, Venezuela).
- Costs increasing but most except shale and coal will continue @ >$30/bbl.
- Unlikely to exceed 10% of world supply before 2020.
- Market problems for specialty streams: degrade or dilute high value products with very high energy input
- North Field gas → *steam in Athabasca* and *corn ethanol in South Dakota*?

  "It's a funny old world." Margaret Thatcher, 1990
- Could a 'Type SCO' one day emerge as a reference crude?

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