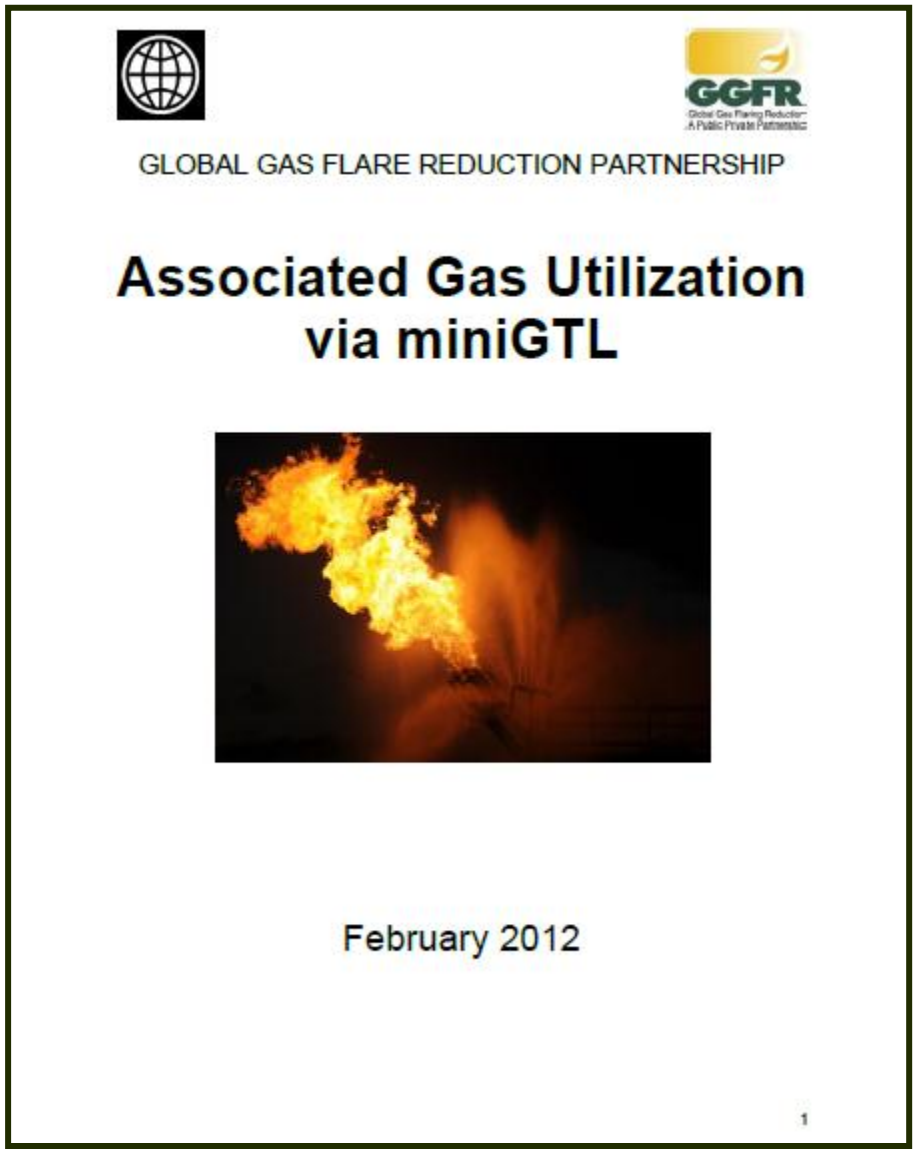
Gas Monetization via Emerging “mini-GTL” Options

GLOBAL METHANE INITIATIVE – Middle East Meeting

Washington, October 2-3, 2012

Dr. Theo H Fleisch

GGFR Study with Final Report in February 2012



Study Lead:
Martyn Howells
Bent Svensson

Study Research:
Theo Fleisch

Time:
1H 2011
Update in February 2012

Available to GGFR members

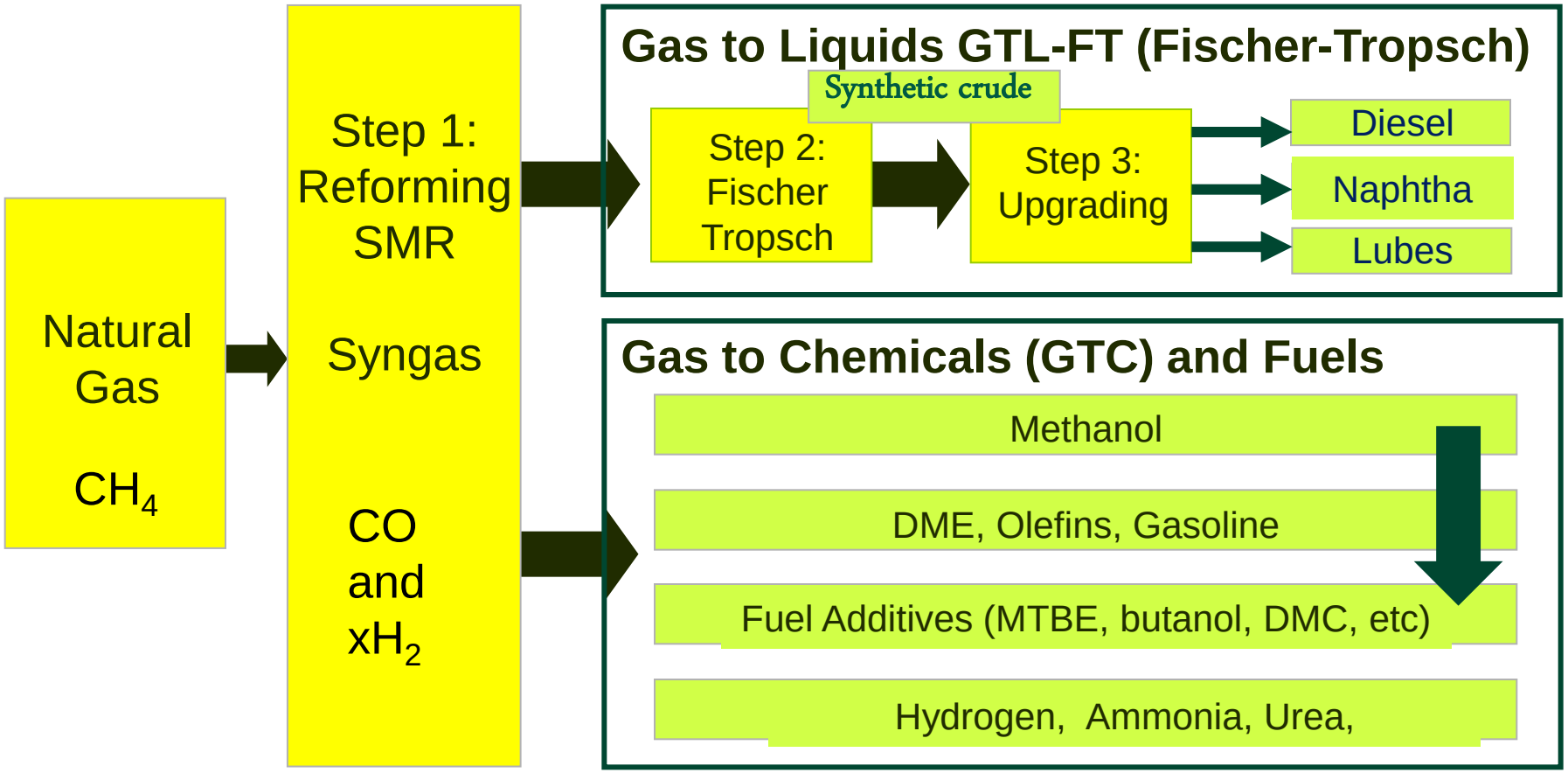
Major Conclusions

- Large scale GTL technologies are proven and profitable (Shell, Sasol , Methanex, etc)
- A few “miniGTL” technologies are for the 1st time commercially available to reduce global gas flaring and monetize smaller gas volumes
- Most of these technologies are based on proven “syngas” routes and have been demonstrated in pilot plants
- Onshore and Offshore applications are possible
- Economic returns look attractive because of the high value products associated with high crude prices

Why GTL?

- **Monetize "stranded" gas** (Trinidad, Qatar,…)
- **Add value to gas** (gas/oil arbitrage: $4/MMBTU to $20/MMBTU in US today)
- **Valuable products**
  - Synthetic crude oil
  - Clean drop-in fuels (gasoline, diesel)
  - Advanced fuels and chemicals (DME, methanol, etc)
- **Energy security**
  - Reduction of imported fuels (1 bcfd/280million m^3 gas per day equates to 1MMbpd)
  - Domestic production (investments, jobs)

GTL: Gas to Liquids – Broad Product Options



Natural gas requirements

- Methane is the preferred feedstock (separation and sale of condensates and NGL)
- However, C2+ (ethane and higher) can be accommodated with minor modifications if gas fractionation is not feasible
- Poisons such as sulfur and mercury must be removed
- Nitrogen and carbon dioxide are diluents and can be tolerated in moderate concentrations
- Pressure is an advantage since the 1st step reformers run at elevated pressures (>20bar)
- Gas feed rates as steady as possible for 10+ years
- Minimum gas feed rate: 50kscfd

Some historic GTL conversion plants

Large scale GTL plants: economy of scale

Plant	Country	Gas Feed Rate	Product	Production
Shell Bintulu	Malaysia	3.4mm m^3/d	Diesel+	12,000bpd
Mossgas	South Africa	6.8mm m^3/d	Diesel+	24,000bpd
Sasol Oryx	**Qatar**	**10mm m^3/d**	**Diesel+**	**35,000bpd**
Shell Pearl	**Qatar**	**40mm m^3/d**	**Diesel+**	**140,000bpd**
Titan	Trinidad	2.1mm m^3/d	methanol	2500tpd
Atlas	Trinidad	4.2mm m^3/d	methanol	5000tpd
Escravos	Nigeria 2013	10mm m^3/d	Diesel+	35,000bpd
Sasol Karshi Uzbekneftegaz	Uzbekistan (planned)	10.8mm m^3/d	Diesel+	38,000bpd
SasolTalisman	Canada (planned)	14-28mm m^3/d	Diesel+	50,000-100,000bpd
Sasol Louisiana	USA (planned)	23mm m^3/d	Diesel+	80,000bpd

Challenges with flared gas for mini-GTL

- **No economy of scale**
  - High capital costs with low financial returns ?
- **Very remote locations and lack of infrastructure**
  - Delivery of bulky equipment
  - Additional costs for utilities
- **Gas production profiles (declining with time)**
  - Original plant size becomes underutilized
- **Local markets for products**

Need for small scale, modular, low cost process units with flexible capacity and for readily useable products

Companies developing mini-GTL technologies

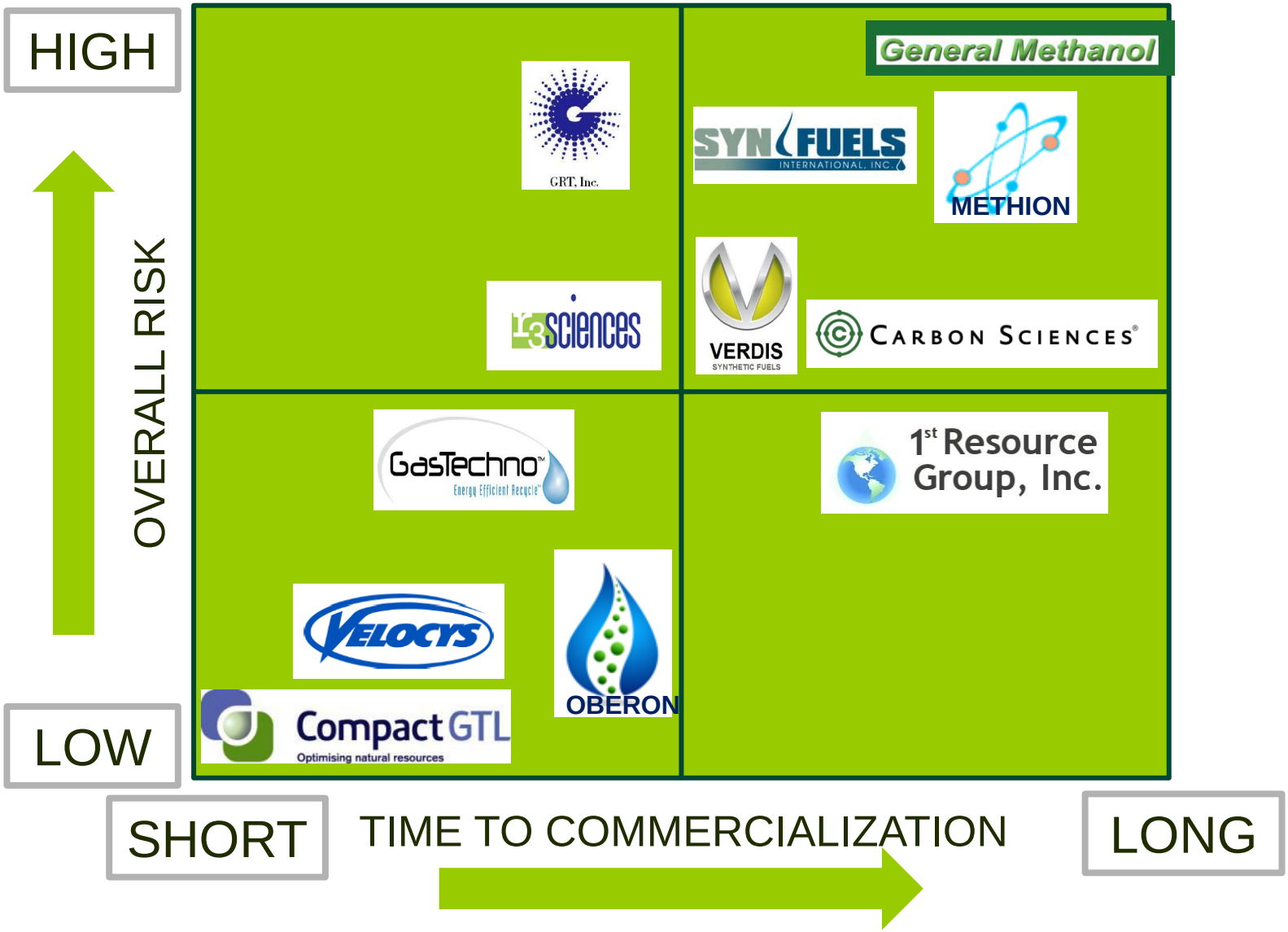
GRT, Inc.

VERDIS
SYNTHETIC FUELS

Evaluation of technologies

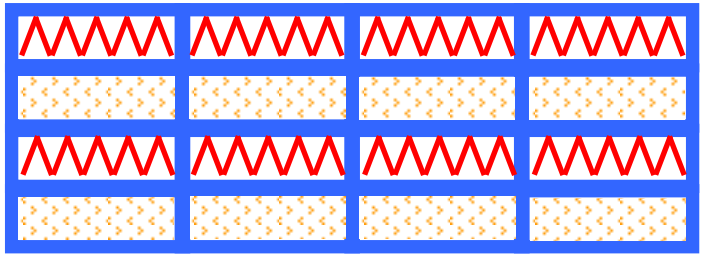
- **Overall technical risks**
- **Status of technology development**
  - Laboratory, pilot plant and demonstration plant status
  - Remaining hurdles
- **Overall Commercial readiness (onshore and offshore)**
- **Size applicability**
  - Small: <1mmscfd (<28,000m^3/d)
  - Medium: 1 -10mmscfd (28,000 – 280,000m^3/d)
  - Large: >10mmscfd (>280,000m^3/d)

Overall Risk and Time to Commercialization



CompactGTL

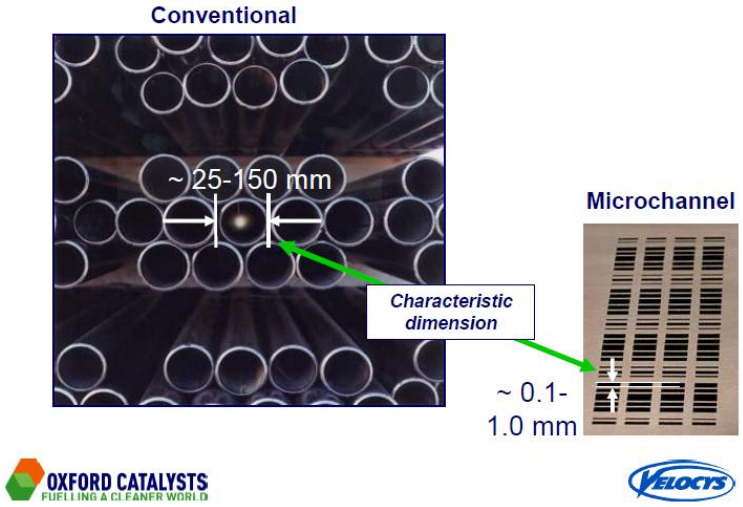
- Technology:
  - process intensified mini-channel reactor technology for both the reformer and the FT unit (~/<5mm)
  - Catalyst placed on metal sheet inserts
  - Effective heat transfer



- Product: diesel or waxy syncrude
- Successful 20bpd demonstration plant (Petrobras)
- Numerous commercial feasibility studies
- www.compactgtl.com

Velocys (Oxford Catalysts)

- Technology:
  - Breakthrough micro-channel technology
  - Reactor channels are <1mm diameter
  - Catalyst coating inside



- Very compact modular design
- Reactor modules can be removed when gas production falls

Velocys: status and path foward

- Commercial development is underway
  - 3 demonstration projects underway (<1MMscfd) in Brazil, Austria and the USA
- All GTL steps proven by 2012 (SMR, FT, Hydrocracking)
- Velocys is accepting commercial orders for FT units now (have already sold about 10 FT reactors)
- Rosneft purchased a 100bpd unit for Angarsk refinery, Siberia, converting 10mm m^3/y
- Calumet (PA) will build 1000bpd unit
- Multiple feasibility studies underway
- www.velocys.com

GASTECHNO: Overview

- Relatively simple technology:
  - Direct oxidation of methane to methanol (no catalyst, no syngas)
  - Modular, skid mounted design
- Technology proven in 50kscfd (1400 m^3/d) demo with good mass and energy balance
- By-products: formalin, ethanol
- Modules available for sale or lease (~/<30,000m^3/d)
- Basic evaluation and engineering packages (28,000 to 850,000m^3/d)
- www.gastechno.com

OBERON FUELS: Overview

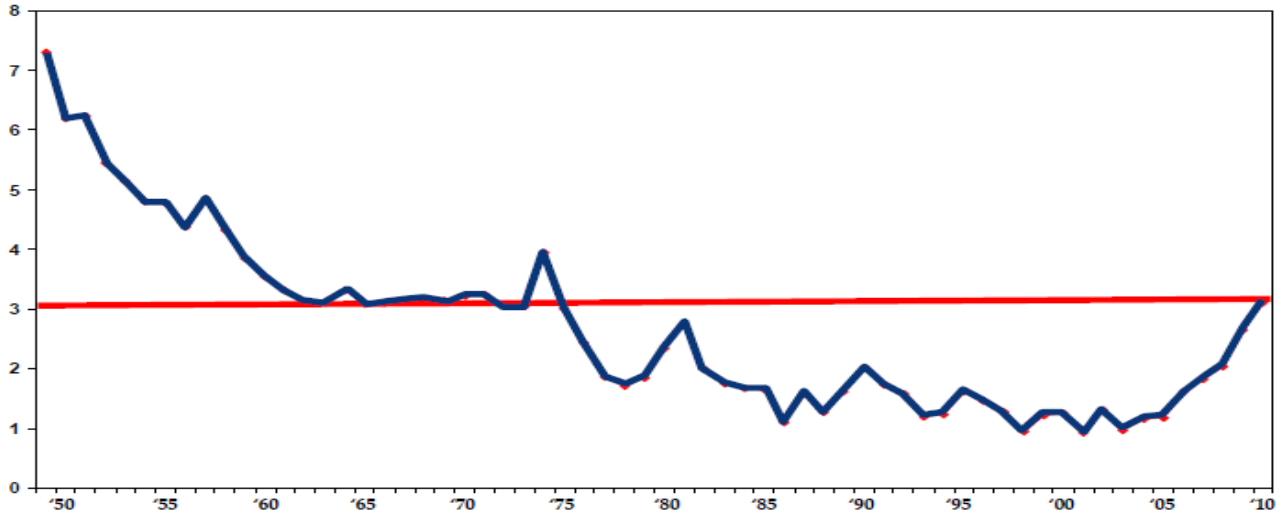
- TECHNOLOGY
  - Skid mounted DME
  - Modular design
  - Targets are small natural gas and/or biogas sources (<2MMscfd or <50,000m^3/d)
  - Markets: local heavy duty diesel fleets converted to DME
- 1st plant to be built in CA in 2013 (feed is methanol)
- 2nd plant will demonstrate the whole chain from natural gas
- www.oberonfuels.com

ECONOMICS BALLPARK ESTIMATOR

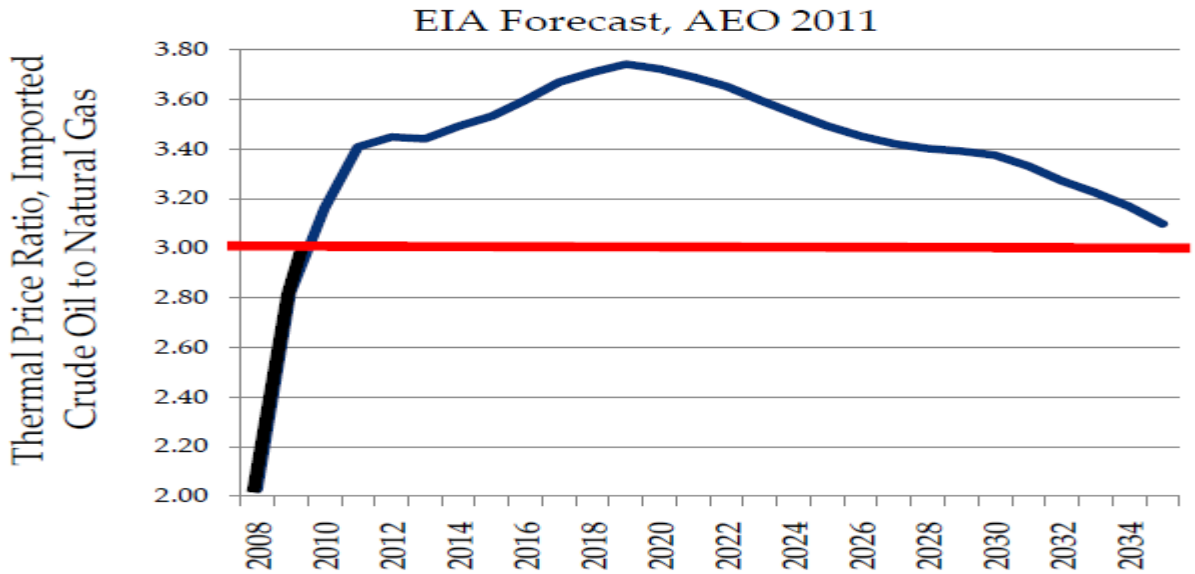
- **Attractive economics**: product/feedstock thermal value spread is >3
  - E.g. gas at $4/MMBTU and diesel at $20/MMBTU equals spread of 5
- **Plant size**
  - 10,000scfd (280m^3/d) == 1bpd liquid product

  Example: 5MMscfd (140,000m^3/d) == 500bpd
- **Capex**
  - ~$80,000/daily barrel
  - 500bpd plant: ~$40MM +/-50%
- **Annual revenue**: ~$17MM (at $100/barrel and 350 days of operation)
  - Minus Opex: ~$3MM
  - Minus gas cost
  - Carbon credits?

Oil-gas spread: past, present and future



GTL economics works well at oil-gas spreads at 3 and above



Conclusions

- The GTC and GTL industries are global and well established
- A few “miniGTL” are now available to reduce global gas flaring and monetize smaller gas volumes
- Most of these technologies are based on proven syngas routes and have been demonstrated in pilot plants
- Offshore applications are possible
- Economics look attractive because of the high value products associated with high crude prices
- Numerous other technologies are under development and some might see commercialization within the next 5 years

Recommendations

- Evaluate mini-GTL technologies as potential new options

- Time is right for commercial applications
  - CompactGTL
  - Velocys
  - Oberon Fuels
  - Gastechno

- The World Bank GGFR Partnership is ready to assist you
  - Martyn Howells: hhowells@worldbank.org
  - Theo Fleisch: theo.fleisch@gmail.com