BP GTL Plant

Nikiski, Alaska

3 MMscfd of natural gas

300 bpd product

Small Scale Gas Monetization via miniGTL Options

Dr. Theo H Fleisch

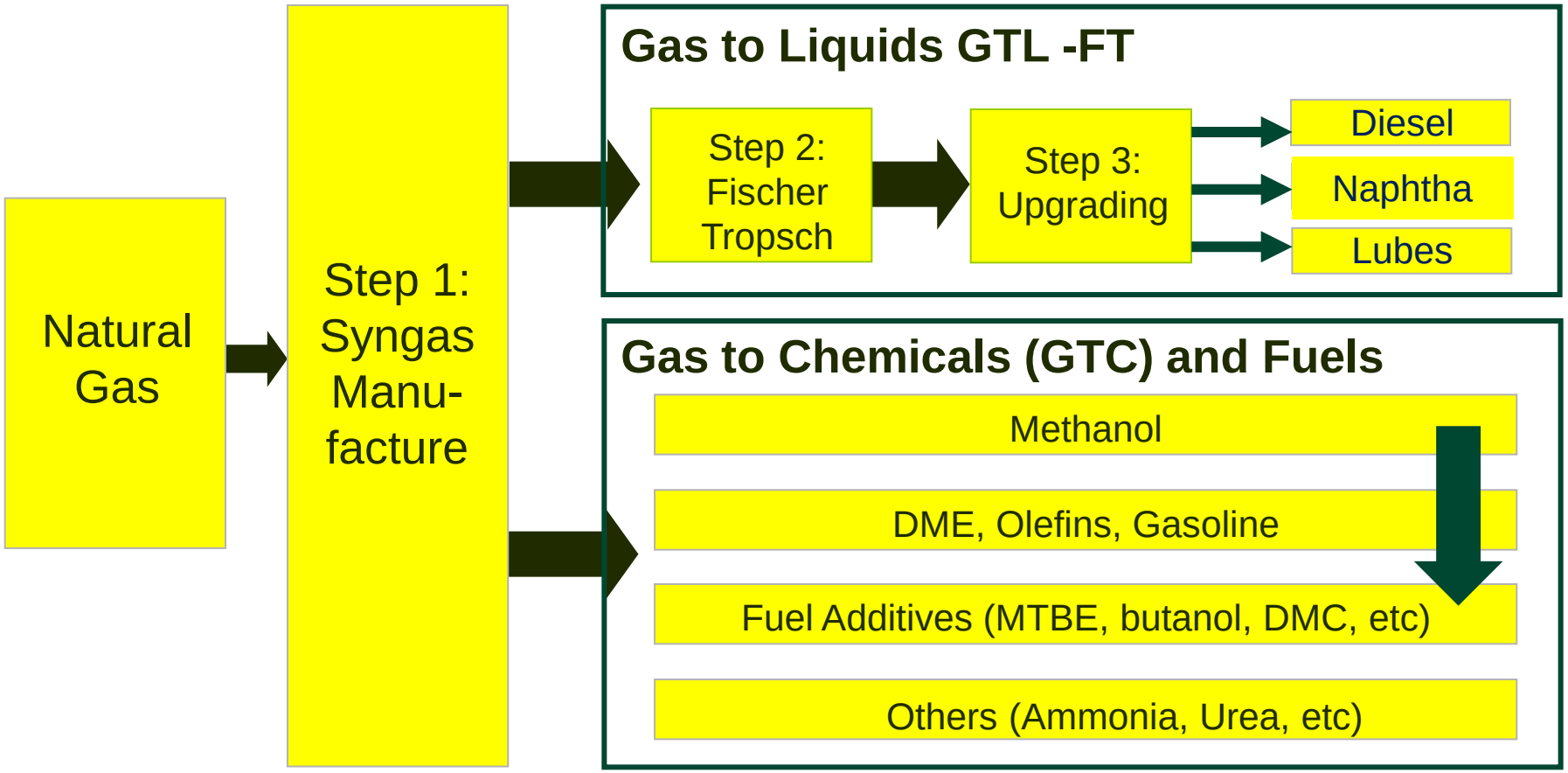
Commissioned by World Bank

Global Gas Flaring Reduction (GGFR) Partnership

GGFR Partnership: Sponsor of study

- Problem: 5 TCF associated gas (AG) flared in 2010
  - Equal to 20% of US consumption
  - 320MM tons of unnecessary CO2 emitted into atmosphere
- Solution: Development and adoption of viable AG utilization options
  - Compressed natural gas (CNG)
  - Liquefied natural gas (miniLNG)
  - Gas to Wire (GTW)
  - **Gas to Liquids (miniGTL)**
  - **Gas to Chemicals (miniGTC)**

GTL: Gas to Liquids – Broad Product Optionality

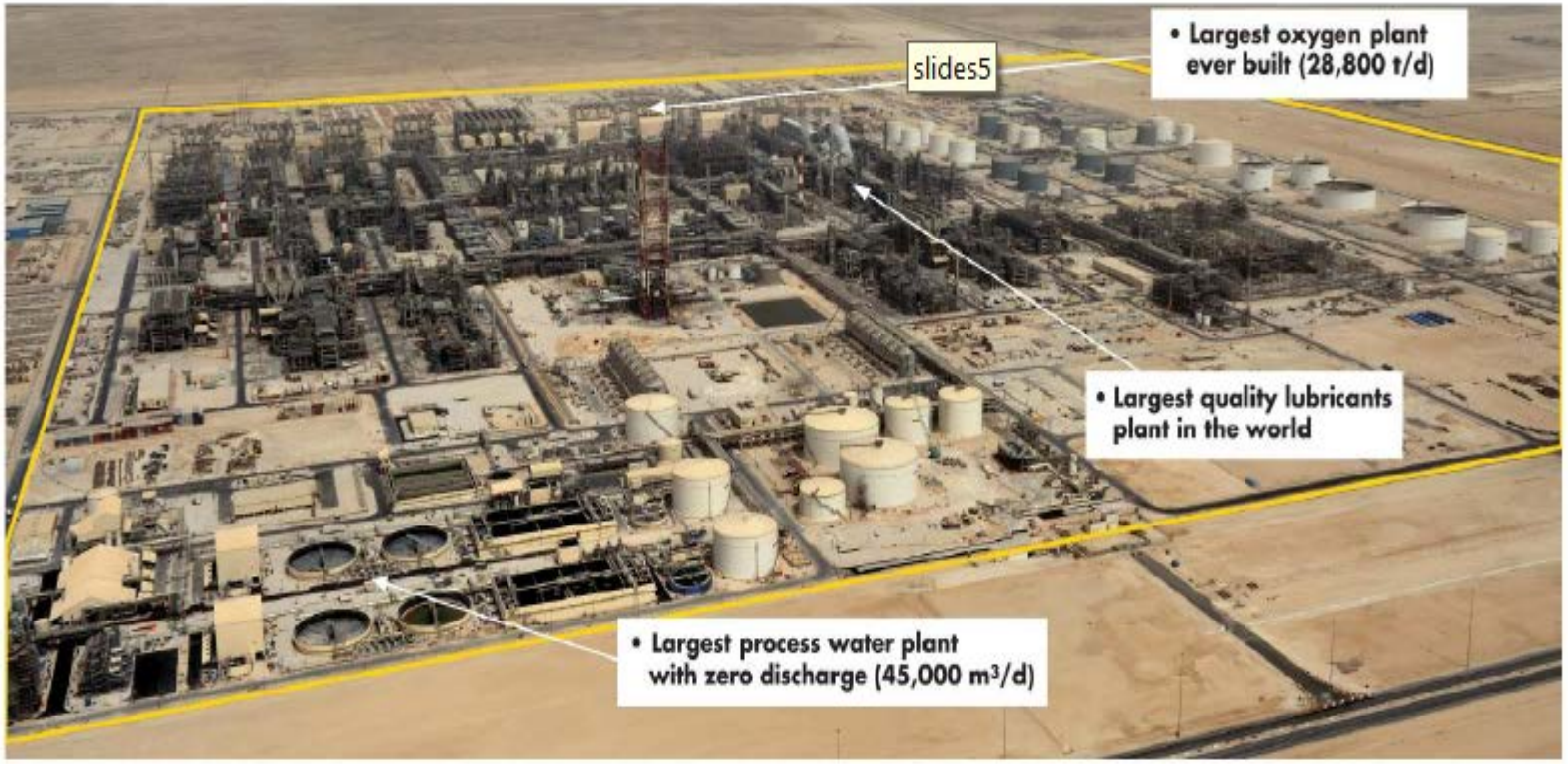


Why GTL?

- Monetize stranded/flared gas
- Add value to gas (gas/oil arbitrage: $4/MMBTU to $20/MMBTU)
- Value added products
  - Clean drop-in designer fuels (gasoline, diesel, jet, butanol)
  - Advanced fuels and chemicals (DME, methanol, etc)
- Energy security
  - Reduction of imported fuels (10bcfd gas equates to 1MMbpd)
  - Domestic production (investments, jobs)

Some historic conversion plants

Pearl GTL: 1st Mega Plant
1.4bcfd gas to 140,000bpd liquid products



- 250 ha on plot area, size of Hyde Park and Kensington Gardens

- 500 million hours to design and construct

GTL projects in the US

- Past: Only North Slope gas was considered for GTL
- Today:
  - Sasol pursues a GTL project in Lousiana
  - Shell announced a “Pearl clone” study in Lousiana
  - MiniGTL opportunities are becoming available

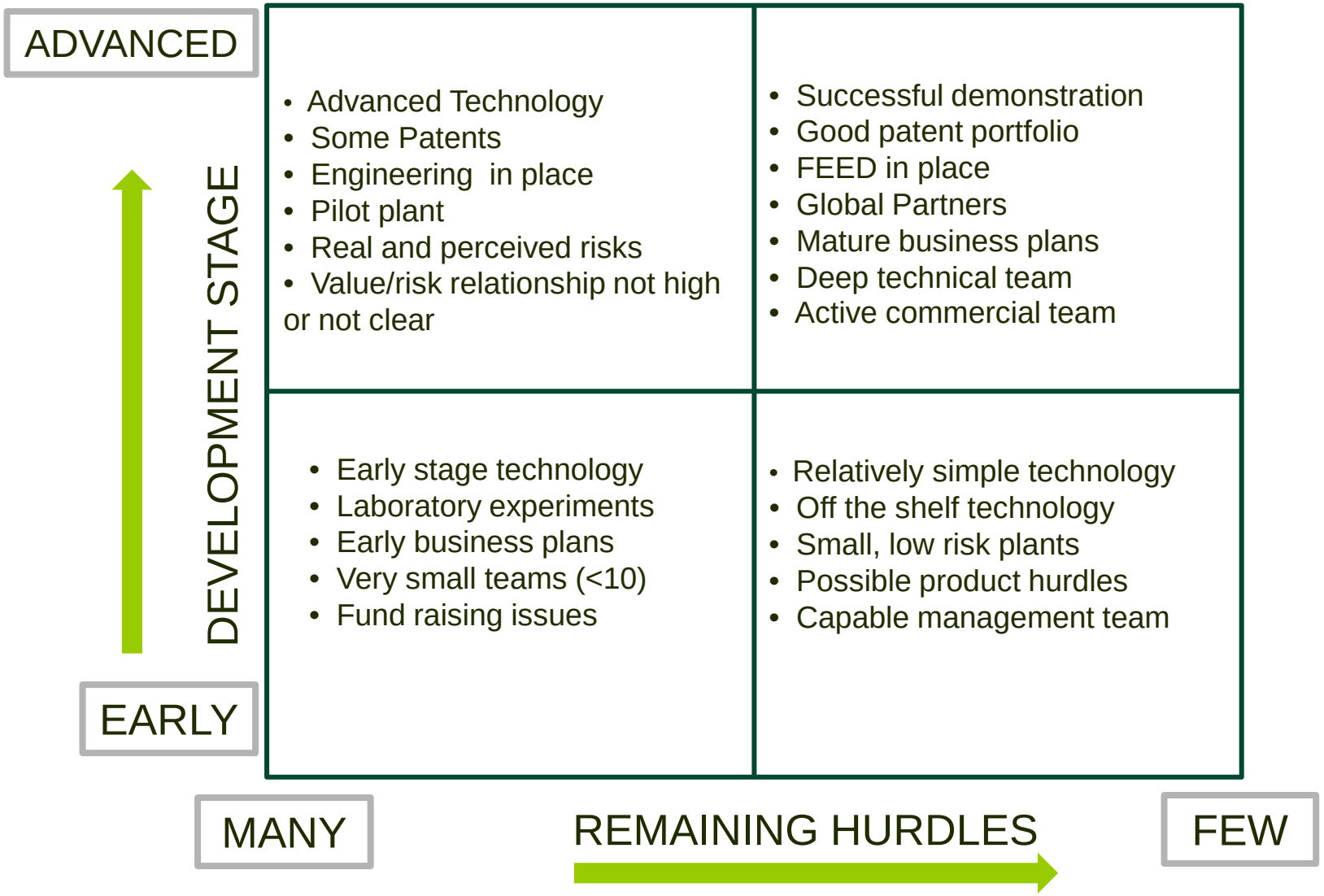
Small is beautiful: “miniGTL”

GRT, Inc.

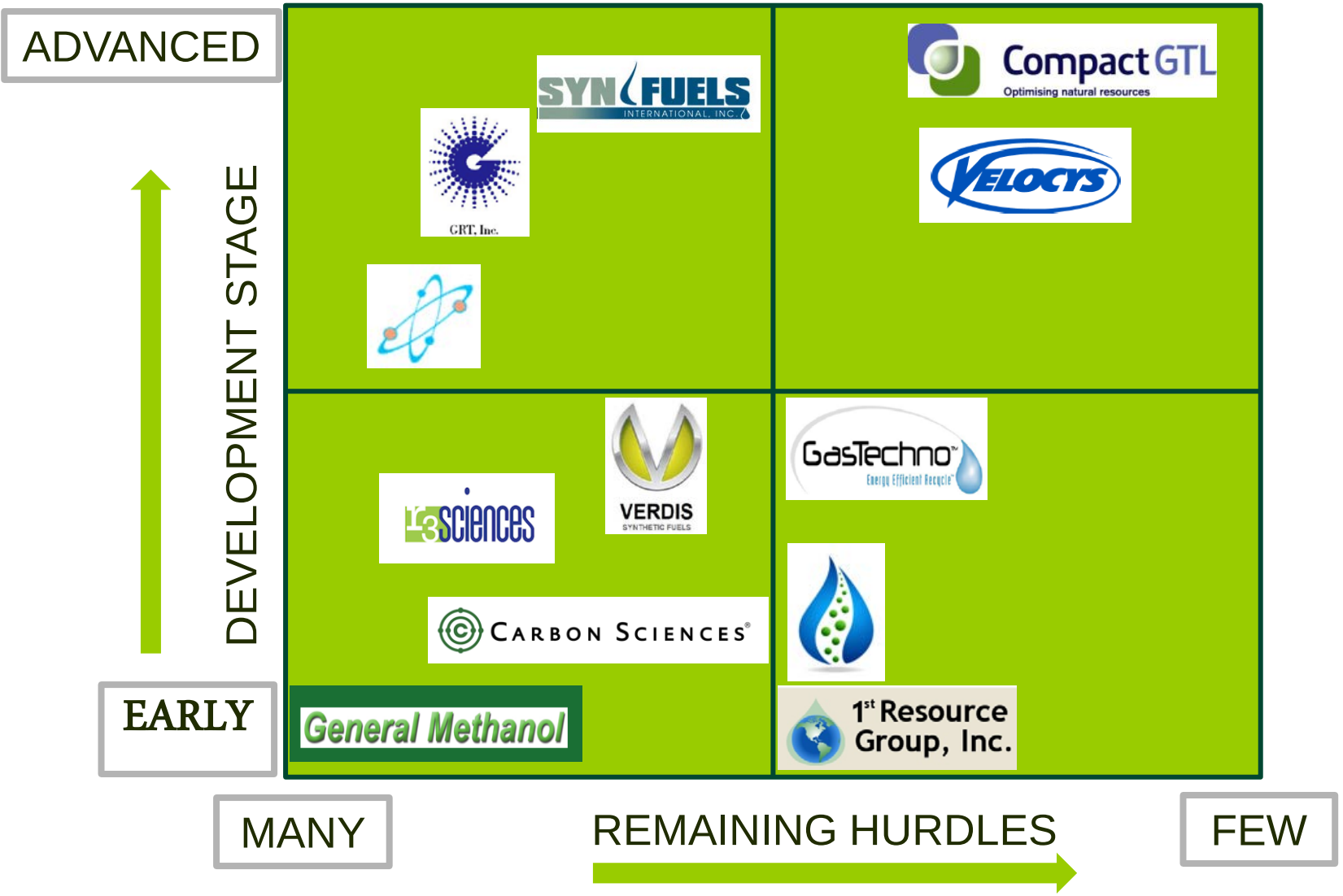
Technology risk: commercial vs unproven

Technology	Reactant	Intermediate	Products	Commercial	COMPANIES
GTL-FT	O_2, H_20, air	syngas	Diesel, others	**YES**	COMPACTGTL, VELOCYS, VERDIS, 1st RESOURCE, CARBONSCIENCES
Methanol	O_2, H_20, air	syngas	Methanol & derivatives	**YES**	OBERON R3SCIENCES
Partial Oxidation (POX)	O_2	none	Methanol & formaldehyde	**NO**	GASTECHNO GENERAL METHANOL
Pyrolysis	none	acetylene	Gasoline	**NO**	SYNFUELS
Oxybromination	Br_2, air	CH_3Br	Gasoline	**NO**	GRT
Methane Sulfonation (MSA)	SO_3, air, Radical initiator	CH_3SO_3H MSA	Methanol & derivatives	**NO**	METHION

Classifying the companies



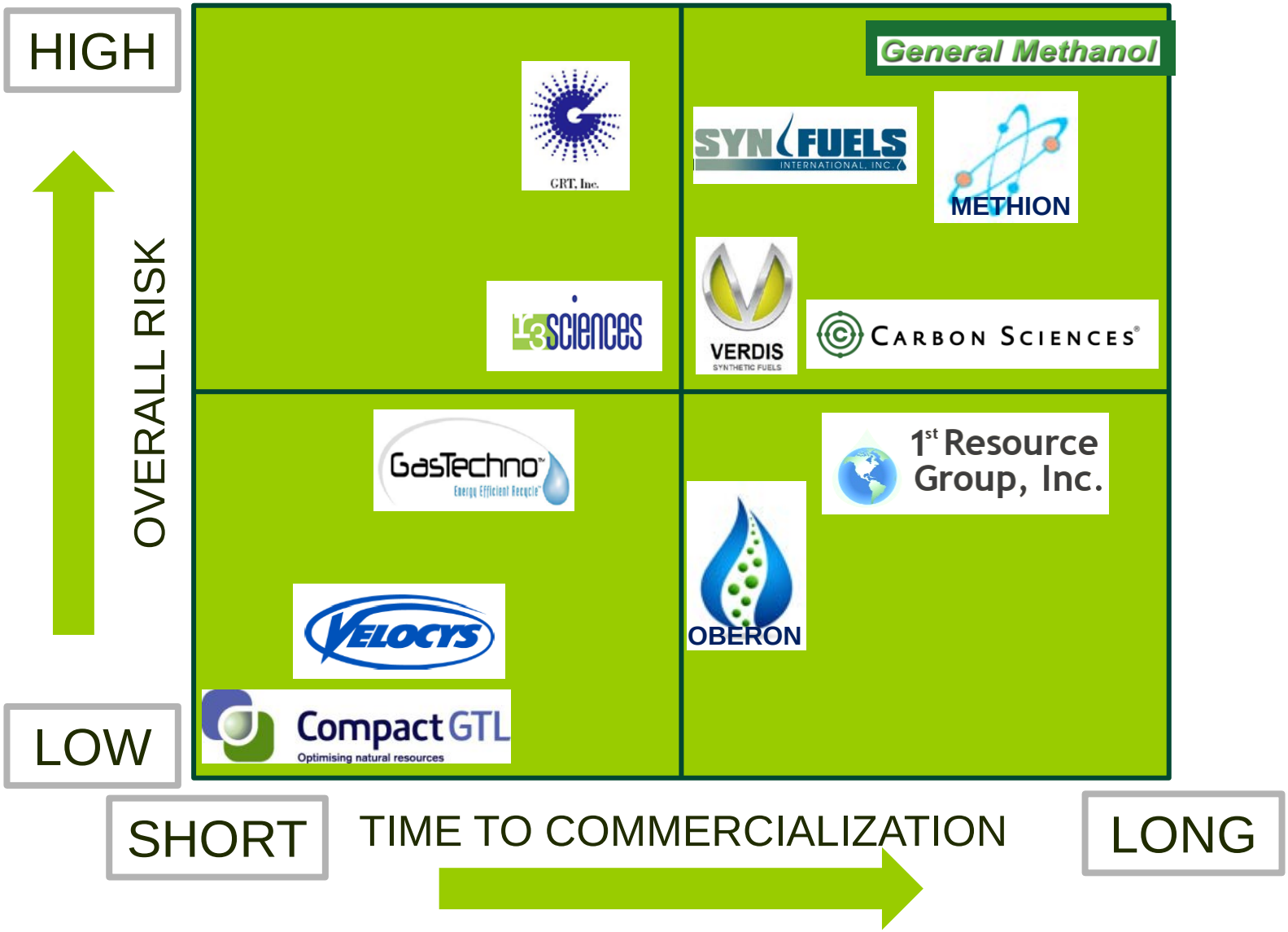
Classifying the companies



Project size applicability

COMPANY	SMALL <1MMscfd	MEDIUM 1-10MMscfd	LARGE >10MMscfd	Offshore Applicable
VERDIS				
1st RESOURCE				
OBERON FUELS				
R3SCIENCES				
GENERAL METHANOL				
CARBON SCIENCES				
GASTECHNO				
METHION				
VELOCYS				
COMPACTGTL				
GRT				
SYNFUELS				

Overall Risk and Time to Commercialization

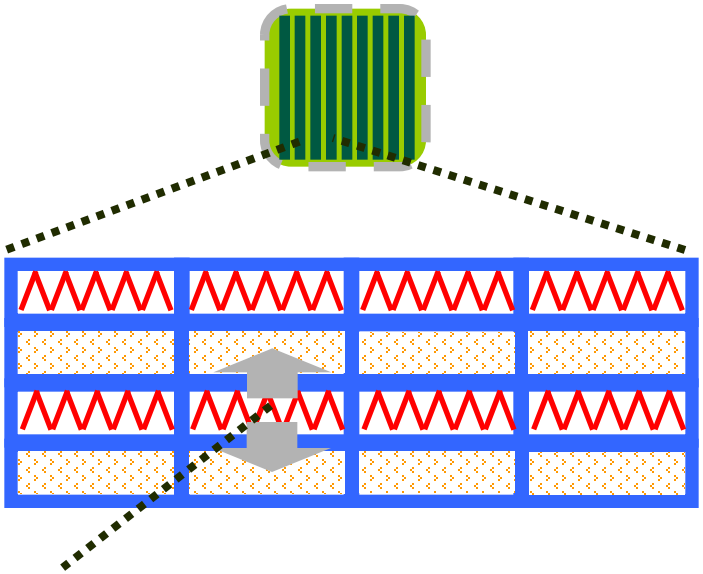


COMPACT GTL (CGTL)

www.compactgtl.com

CompactGTL: Process intensified mini-channel FT

Compact
FT
Reactor

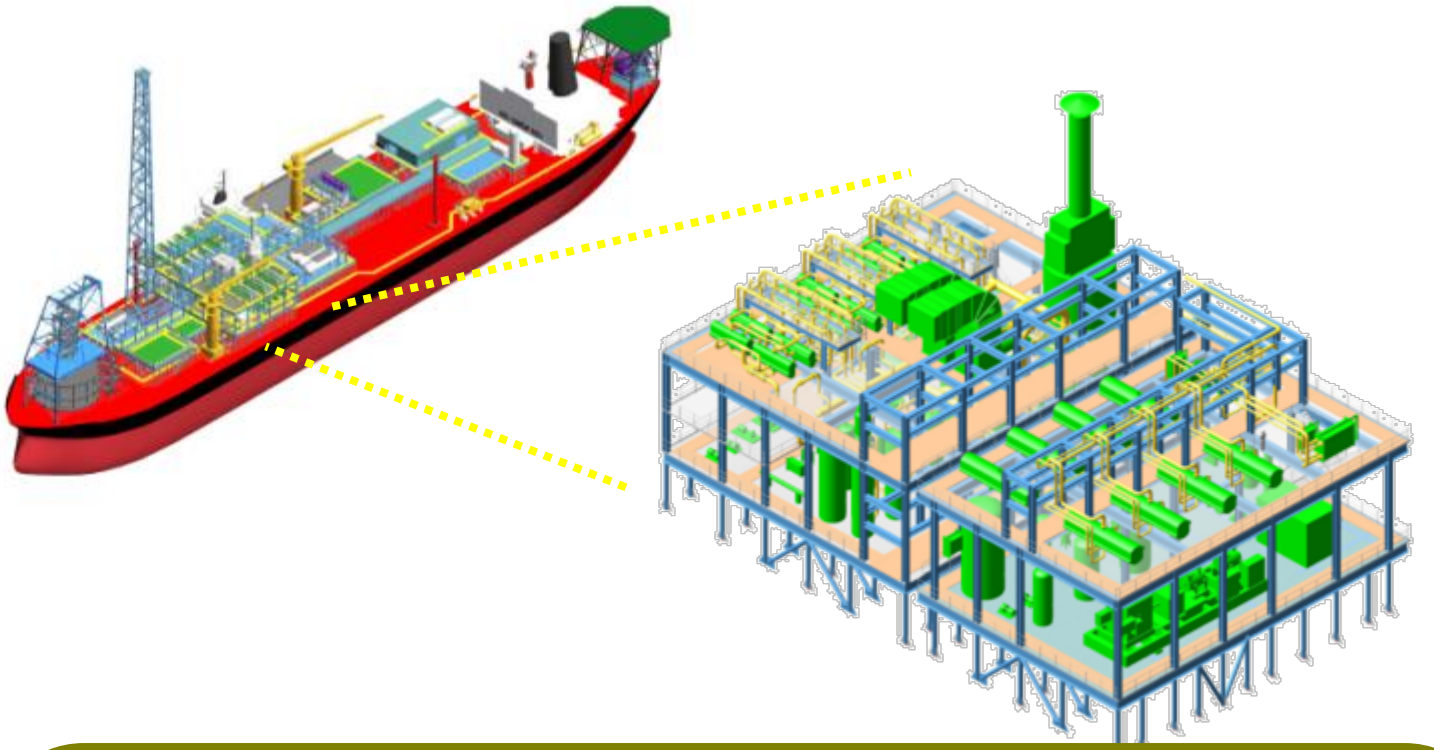


FT catalyst foil inserts

FT Stream
Coolant Stream

High heat transfer from
FT process stream into
coolant stream

CompactGTL Solution @ 2-50 MMscfd



Integrate the GTL plant with the production facility

Convert the associated gas into syncrude

Co-mingle and transport with the natural crude

CompactGTL: Picture of Petrobras pilot plant

Image shown courtesy of Petrobras

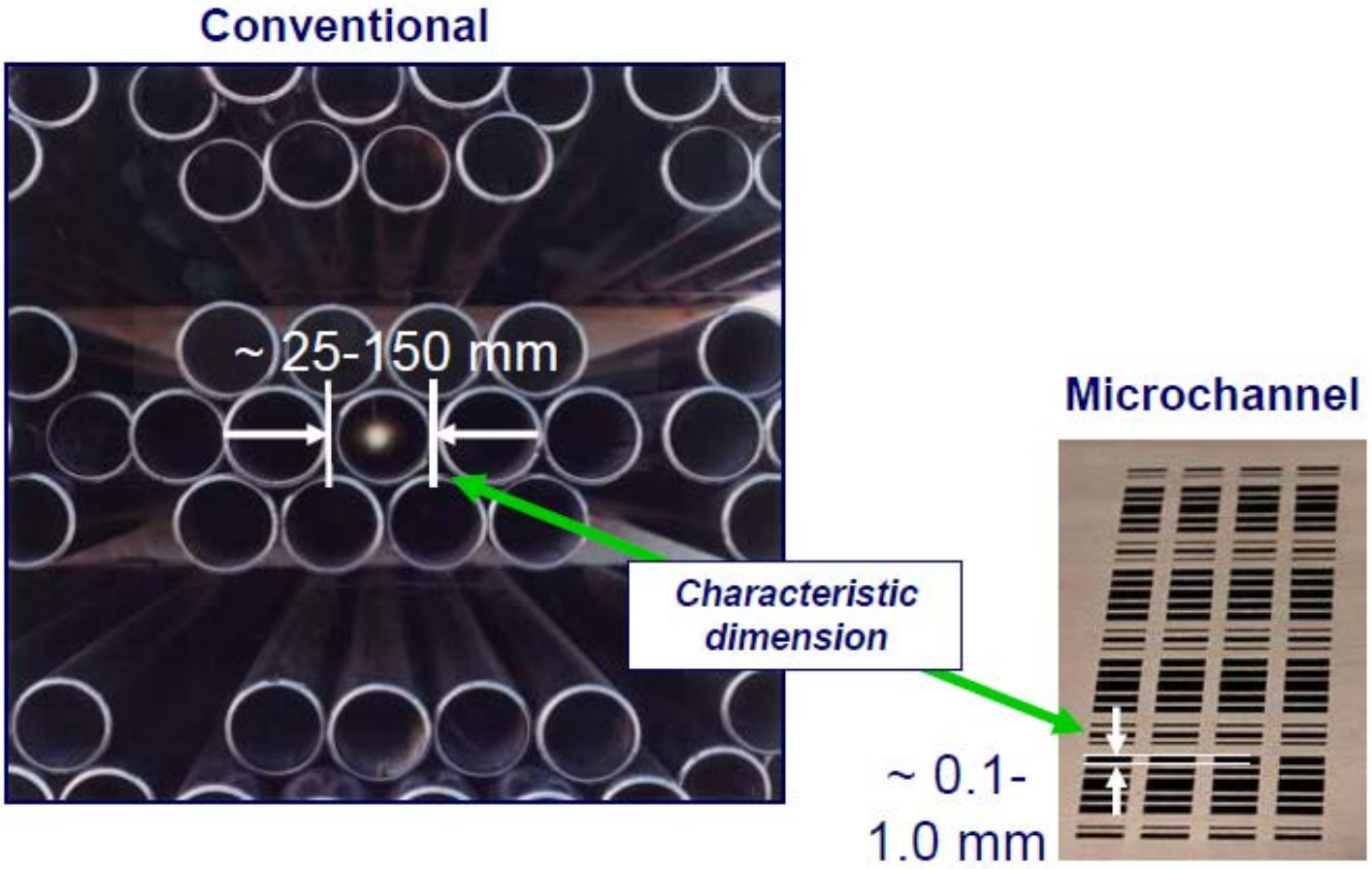
CompactGTL: Status and path forward

- 20bpd Brazil demo plant passed Petrobras acceptance test (1Q12)
- Numerous commercial feasibility studies underway
- Offshore and onshore applications
- Petrobras pursues 10MMscfd offshore project
- www.compactgtl.com
- Contact: Subby Bains

VELOCYS and OXFORD CATALYSTS

www.oxfordcatalysts.com
www.velocys.com

OCV: MICROCHANNEL PROCESS TECHNOLOGY (MPT)



OXFORD CATALYSTS
FUELLING A CLEANER WORLD

VELOCYS

VELOCYS: micro-channel processing technology

SMR: CONVENTIONAL & NEW

FT REACTOR

Velocys: status and path foward

- Commercial development is underway
  - 3 demo projects underway (<1MMscfd)
- All GTL steps proven by 2012 (SMR, FT, Hydrocracking)
- Velocys is accepting commercial orders for FT units now (have already sold 4 FT reactors)
- Multiple feasibility studies underway
- www.velocys.com
- Contact: Jeff McDaniels

GASTECHNO

Gas Technologies LLC

GASTECHNO: Overview

- Relatively simple technology:
  - Direct oxidation of methane to methanol (no catalyst, no syngas)
  - Trick: product separation and recycle
  - Modular, skid mounted design
- Technology proven in 50kscfd demo with good mass and energy balance
- By-products: formalin, ethanol
- Modules available for sale or lease (~/<1MMscfd)
- Basic evaluation and engineering packages (1 to 30 MMscfd)
- www.gastechno.com
- Contact: Walter Breidenstein

OBERON FUELS

www.oberonfuels.com

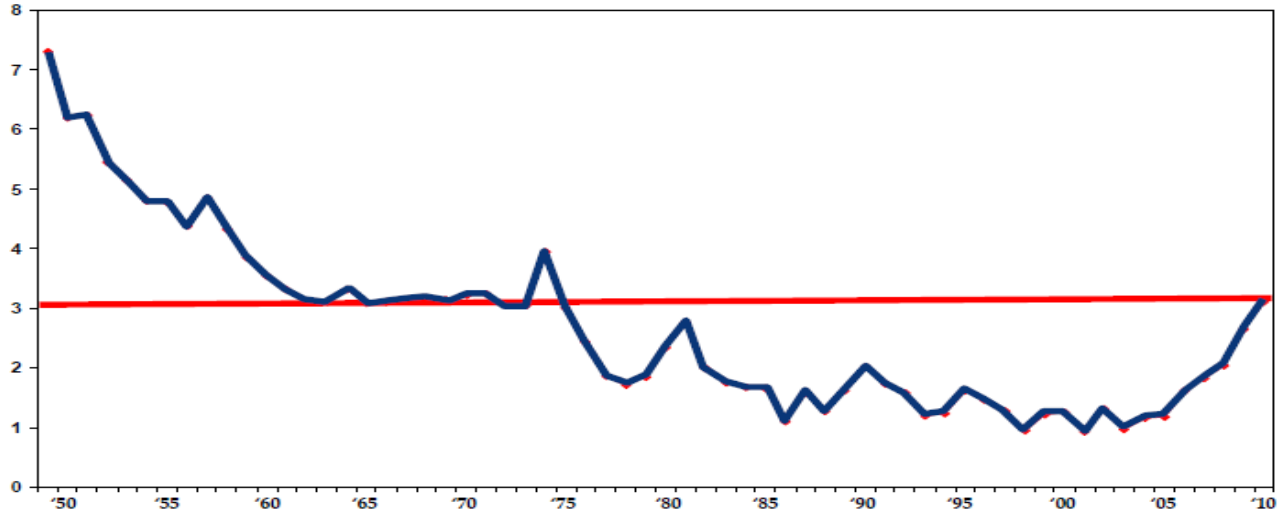
OBERON FUELS: Overview

- TECHNOLOGY
  - Skid mounted DME
  - Modular design
  - Targets are small gas, biogas sources (<2MMscfd)
  - Markets: local heavy duty diesel fleets converted to DME
- 1st plant to be built in CA in 2012 (feed is methanol)
- 2nd plant will demonstrate the whole chain from natural gas
- www.oberonfuels.com
- Contact: Rebecca Breitenkamp

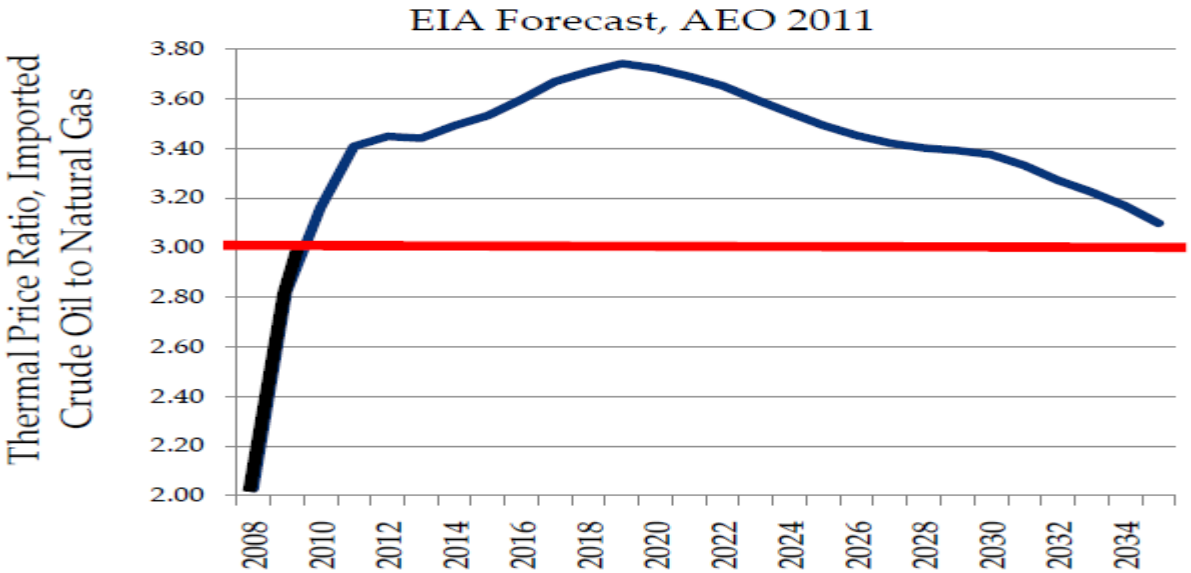
ECONOMICS BALLPARK ESTIMATOR

- Attractive economics: product/feedstock value spread is >3
- Plant size
  - 10,000scfd == 1bpd liquid product
  - 5MMscfd == 500bpd
- Capex
  - ~$80,000/daily barrel
  - 5MMscfd plant: ~$40MM +/-50%
- Annual revenue: ~$17MM (at $100/barrel and 350 days of operation)
  - Minus Opex: ~$2MM
  - Minus gas cost

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

THANK YOU

My thanks go to:

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Bent Svensson

GGFR, World Bank