

Methanol to Gasoline

Table of Contents

A Report by Nexant's CHEMSYSTEMS
Process Evaluation/Research Planning (PERP) Program
PERP 2011S7 - Published May 2012

www.chemsystems.com

Section	Page
1 Executive Summary	1
1.1.1 Sources of Methanol	1
1.1.2 Methanol as Automotive Fuel.....	1
1.1.3 Methanol as a Blending Feedstock (M15 & M85) in Automotive Fuel	2
1.1.4 Applications and Relevant Government Policies	2
1.1.5 Strategic, Technical, and Commercial Considerations of Methanol Gasoline versus Gasoline from Methanol	2
1.2 CHEMISTRY	4
1.2.1 MTG Chemistry	4
1.3 MTG TECHNOLOGY	4
1.5 RECENT TECHNOLOGY AND COMMERCIALIZATION DEVELOPMENT	7
1.6 STATUS OF MTG COMMERCIALIZATION AND OPERATIONS.....	7
1.6.1 Outlook of MTG Technologies.....	8
1.7 ECONOMIC ANALYSIS	8
1.7.1 China (Shanxi Province).....	8
1.7.2 United States Gulf Coast (USGC)	11
1.8 COMMERCIAL ANALYSIS.....	13
1.8.1 Global Overview	13
2 Introduction	16
2.1 COAL TO GASOLINE	16
2.2 HISTORY OF THE METHANOL TO GASOLINE (MTG) PROCESS	17
2.2.1 Development of MTG Process in New Zealand.....	17
2.3 SOURCES OF METHANOL.....	18

2.3.1	Methanol from Natural Gas	18
2.3.2	Methanol from Coal.....	20
2.4	METHANOL AS AUTOMOTIVE FUEL	23
2.4.1	Direct use of Methanol as Automotive Fuel.....	23
2.4.2	Methanol as Fuel Blending Feedstock (M15 & M85).....	25
2.4.3	Applications and Relevant Government Policies	26
2.5	STRATEGIC, TECHNICAL, AND COMMERCIAL CONSIDERATIONS OF METHANOL GASOLINE VERSUS GASOLINE FROM METHANOL.....	26
2.6	ORGANIZATION OF THE REPORT.....	29
3	Chemistry and Technology	30
3.1	METHANOL TO GASOLINE (MTG) CHEMISTRY	30
3.1.1	MTG Chemistry and Reaction Mechanism	30
3.1.2	Zeolite Socony Mobil # 5 (ZSM-5) Catalyst	31
3.2	ORIGINAL MOBIL MTG PROCESS – FIXED BED PROCESS.....	33
3.3	URBK-UHDE-MOBIL MTG PROCESS – FLUID BED PROCESS	38
3.4	LURGI-MOBIL MTG PROCESS – MULTI TUBULAR FIXED- BED REACTOR.....	40
3.5	COMPARISON OF TRADITIONAL MTG PROCESS.....	43
4	Recent Technology and Commercialization Development	45
4.1	RECENT METHANOL TO GASOLINE (MTG) TECHNOLOGY DEVELOPMENTS.....	45
4.1.1	Second Generation ExxonMobil MTG Process.....	45
4.1.2	One-Step MTG Process	45
4.2	OTHER TECHNOLOGIES.....	46
4.2.1	Topsoe Integrated Gasoline Synthesis (TIGAS) Process	46
4.3	STATUS OF MTG COMMERCIALIZATION AND OPERATIONS.....	48
4.4	OUTLOOKS OF MTG TECHNOLOGIES.....	48
5	Process Economics	50
5.1	BASIS	50
5.1.1	Pricing Basis	50
5.1.2	Investment Basis	51
5.1.3	Cost of Production Definitions	52
5.2	METHANOL TO GASOLINE COST OF PRODUCTION ESTIMATES - CHINA LOCATION BASIS.....	53

5.2.1	Gasoline Production using Coal-based Methanol.....	53
5.2.2	Gasoline Production using Natural Gas-Based Methanol	60
5.2.3	Gasoline Production using Purchased Methanol	67
5.3	METHANOL TO GASOLINE COST OF PRODUCTION ESTIMATES – U.S. LOCATION BASIS.....	72
5.3.1	Gasoline Production using Coal-Based Methanol	72
5.3.2	Gasoline Production using Natural Gas-Based Methanol	80
5.3.3	Gasoline Production using Purchased Methanol	86
5.4	COST COMPARISON	90
5.4.1	China	90
5.4.2	United States Gulf Coast.....	93
6	Commercial Analysis	96
6.1	GLOBAL OVERVIEW	96
6.1.1	Demand	96
6.1.2	Current and Planned Refining Capacity	96
6.1.3	Supply	98
6.1.4	Net Trade	100
6.2	REGIONAL MARKET ANALYSIS	101
6.2.1	North America	101
6.2.2	South America	103
6.2.3	Western Europe.....	105
6.2.4	Eastern Europe	107
6.2.5	Africa	109
6.2.6	Middle East	111
6.2.7	Asia	113
7	Glossary	116
8	References	119

Appendix	Page
A Definitions of Capital Cost Terms Used in Process Economics	A-1
B Definitions of Operating Cost Terms Used in Process Economics	B-1
C PERP Program Title Index (2001/2002 - 2011)	C-1

Figure	Page
1.1 Gasoline Production Cost Comparison - China	10
1.2 Gasoline Production Cost Comparison - USGC	13
2.1 Producing Gasoline from Coal (CTG Route)	17
2.2 Major Gasification Reactions	21
2.3 Flow Scheme for the Production of Methanol from Coal.....	22
2.4 Vapor Pressure of Methanol-Gasoline Blends.....	25
2.5 Price Comparison Among Crude Oil, Gasoline and Methanol.....	27
3.1 Structure of ZSM-5 Catalyst – Pentasil Unit	32
3.2 Structure of ZSM-5 Catalyst – Pentasil Chain.....	32
3.3 Structure of ZSM-5 Catalyst – Corrugated Sheet	32
3.4 Structure of ZSM-5 Catalyst – Channel Structure	33
3.5 Mobil Fixed-Bed MTG Process – Methanol to Raw Gasoline.....	35
3.6 Mobil Fixed-bed MTG Process – Raw Gasoline Upgrading.....	37
3.7 URBK-UHDE-MOBIL Fluid-bed MTG Process	39
3.8 Lurgi-Mobil Multi Tubular MTG Process	42
4.1 TIGAS Process Block Flow Diagram.....	46
5.1 Effects of Coal Price on Gasoline Cost of Production.....	58
5.2 Effects of Total Capital Employed on Gasoline Cost of Production	59
5.3 Effects of Capacity on Gasoline Cost of Production	60
5.4 Effects of Natural Gas Price on Gasoline Cost of Production	64
5.5 Effects of Total Capital Employed on Gasoline Cost of Production	65
5.6 Effects of Capacity on Gasoline Cost of Production	66
5.7 Effects of Natural Gas Price on Gasoline Cost of Production	69
5.8 Effects of Total Capital Employed on Gasoline Cost of Production	70
5.9 Effects of Capacity on Gasoline Cost of Production	71
5.10 Effects of Coal Price on Gasoline Cost of Production.....	77
5.11 Effects of Total Capital Employed on Gasoline Cost of Production	78
5.12 Effects of Capacity on Gasoline Cost of Production	79
5.13 Effects of Natural Gas Price on Gasoline Cost of Production	83
5.14 Effects of Total Capital Employed on Gasoline Cost of Production	84
5.15 Effects of Capacity on Gasoline Cost of Production	85
5.16 Effects of Natural Gas Price on Gasoline Cost of Production	88

5.17	Effects of Total Capital Employed on Gasoline Cost of Production	89
5.18	Effects of Capacity on Gasoline Cost of Production	90
5.19	Gasoline Production Cost Comparison - China	92
5.20	Gasoline Production Cost Comparison - USGC	95
6.1	World Refining Capacity	97
6.2	Global Refining	98
6.3	Regional Refinery Utilization	98
6.4	Global Gasoline Trade	100
6.5	Gasoline Supply, Demand, and Trade in North America	102
6.6	North American Refinery Utilization	103
6.7	Gasoline Supply, Demand, and Trade in South America	104
6.8	South America Refinery Utilization	105
6.9	Gasoline Supply, Demand, and Trade in Western Europe	106
6.10	Western Europe Refinery Utilization	107
6.11	Gasoline Supply, Demand, and Trade in Eastern Europe	108
6.12	Eastern Europe Refinery Utilization	109
6.13	Gasoline Supply, Demand, and Trade in Africa	110
6.14	African Refinery Utilization	111
6.15	Gasoline Supply, Demand, and Trade in the Middle East	112
6.16	Middle East Refinery Utilization	113
6.17	Gasoline Supply, Demand, and Trade in Asia	114
6.18	Asian Refinery Utilization	115

Table	Page
1.1 MTG Gasoline versus U.S. Conventional Refinery Gasoline	3
1.2 Comparison between Fixed-bed and Fluid-Bed MTG Process	6
1.3 Summary of MTG Plants	8
1.4 Gasoline Production Cost Summary - China	9
1.5 Gasoline Production Cost Summary - USGC	12
1.6 Worldwide Refined Products Demand	14
1.7 Worldwide Gasoline Demand by Region	15
2.1 Comparison of Methanol and Gasoline Properties	23
2.2 MTG Gasoline versus U.S. Conventional Refinery Gasoline	28
3.1 Operating Conditions for Fixed-bed MTG Process	36
3.2 Operating Conditions for Fluid-bed MTG Process	40
3.3 Comparison between Fixed-bed and Fluid-Bed MTG Process	44
4.1 Summary of MTG Plants	48
5.1 Price and Utilities Basis	51
5.2 Methanol-to-gasoline Capital Cost Estimates	52
5.3 Cost of Production Estimate for: Syngas Process: Coal Gasification and Water-Gas Shift	55
5.4 Cost of Production Estimate for: Methanol Process: via Syngas (SN = 2:1 H ₂ :CO)	56
5.5 Cost of Production Estimate for: Gasoline Process: ExxonMobil's MTG Process (Coal-Based Methanol)	57
5.6 Cost of Production Estimated for: Methanol Process: via Syngas Derived from Natural Gas	62
5.7 Cost of Production Estimate for: Gasoline Process: ExxonMobil's MTG Process (Natural Gas-Based Methanol)	63
5.8 Cost of Production Estimate for: Gasoline Process: ExxonMobil's MTG Process (purchased methanol)	68
5.9 Cost of Production Estimate for: Syngas Process: Coal Gasification and Water-gas Shift	74
5.10 Cost of Production Estimate for: Methanol Process: via Syngas (SN = 2:1 H ₂ :CO)	75
5.11 Cost of Production Estimate for: Gasoline Process: ExxonMobil's MTG Process (Coal-Based Methanol)	76
5.12 Cost of Production Estimate for: Methanol Process: via Natural Gas	81

5.13 Cost of Production Estimate for: Gasoline Process: ExxonMobil's MTG Process (Natural Gas-Based Methanol).....	82
5.14 Cost of Production Estimate for: Gasoline Process: ExxonMobil's MTG Process (Purchased Methanol).....	87
5.15 Gasoline Production Cost Summary - China.....	91
5.16 Gasoline Production Cost Summary - USGC.....	94
6.1 Worldwide Gasoline Demand by Region	96
6.2 Worldwide Refined Products Supply.....	99
6.3 Worldwide Gasoline Supply by Region	100
6.4 Worldwide Gasoline Net Trade	101

CHEMSYSTEMS

PERP PROGRAM



www.chemsystems.com

The ChemSystems Process Evaluation/Research Planning (PERP) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. PERP reports are available as a subscription program or on a single report basis.

Contact Details:

London: Dr. Alexander Coker, Manager, PERP Program
Phone: + 44-(20)-7950-1570, e-mail: acoker@nexant.com

New York: Heidi Junker Coleman, Global Multi-Client Programs Support Manager
Phone: + 1-914-609-0381, e-mail: hcoleman@nexant.com

Shanghai: Dr. Y. Larry Song, General Manager, Nexant China
Phone: +86 21 6182 6791, e-mail: ylsong@nexant.com

Nexant, Inc. (www.nexant.com) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, ChemSystems has helped clients increase business value through assistance in all aspects of business strategy, including business intelligence, project feasibility and implementation, operational improvement, portfolio planning, and growth through M&A activities. Nexant has its main offices in San Francisco (California), White Plains (New York), and London (UK), and satellite offices worldwide.

Copyright © by Nexant Inc. 2012. All Rights Reserved.