

Methanol Strategic Business Analysis

February 2013



1st Floor, 1 King's Arms Yard, London EC2R 7AF, UK
Tel: +44 20 7950 1600 Fax: +44 20 7950 1550

This Report was prepared by Nexant, Inc ("Nexant") and is part of the SBA Methanol Program. Except where specifically stated otherwise in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge of Nexant. Aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility. Neither NEXANT, Subscriber nor any person acting on behalf of either assumes any liabilities with respect to the use of or for damages resulting from the use of any information contained in this Report. Nexant does not represent or warrant that any assumed conditions will come to pass.

The Report is submitted on the understanding that the Subscriber will maintain the contents confidential except for the Subscriber's internal use. The Report should not be reproduced, distributed or used without first obtaining prior written consent by Nexant. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Copyright © by Nexant Inc. 2013. All rights reserved.

Contents

Section	Page
1 Executive Summary	1-1
2 Introduction	2-1
2.1 OVERVIEW	2-1
2.2 STRUCTURE OF THE REPORT	2-2
2.2.1 Coverage	2-2
2.2.2 Report Contents.....	2-2
3 Key Trends and Challenges	3-1
3.1 INTRODUCTION	3-1
3.2 METHANOL TO GASOLINE REVIVAL.....	3-2
3.2.1 Background	3-2
3.2.2 Chemistry and Technology	3-3
3.2.3 Prospects of MTG Technology	3-5
3.3 NEW TRENDS IN METHANOL PRICING - FUEL AS AN INFLUENCE	3-6
3.4 RESURGENCE OF METHANOL CAPACITY IN THE NORTH AMERICA	3-10
3.5 NATURAL GAS-BASED OLEFINS PROJECTS.....	3-14
4 Market Dynamics	4-1
4.1 INTRODUCTION	4-1
4.2 MARKET DYNAMICS FORECASTING METHODOLOGY	4-2
4.2.1 Capacity Availability and Forecasting.....	4-2
4.2.2 End-Use Consumption Forecasting.....	4-2
4.2.3 Production and Trade Forecasting	4-4
4.3 METHANOL DEMAND.....	4-5
4.3.1 Traditional Uses of Methanol	4-8
4.3.2 Emerging Uses of Methanol	4-18
4.3.3 Technological Developments.....	4-29
4.3.4 Major Methanol Consumers.....	4-30
4.4 SUPPLY.....	4-31
4.4.1 Global.....	4-31
4.4.2 Top Ten Methanol Producers.....	4-34
4.5 SUPPLY/DEMAND AND TRADE	4-41
4.5.1 Global.....	4-41
4.5.2 North America.....	4-44
4.5.3 South America.....	4-45
4.5.4 Western Europe.....	4-46
4.5.5 Central and Eastern Europe.....	4-46
4.5.6 Middle East	4-47
4.5.7 Africa	4-48

4.5.8	Japan	4-49
4.5.9	China	4-49
4.5.10	Other Asia Pacific	4-50
5	Profitability and Pricing	5-1
5.1	NEXANT'S GENERAL PROFITABILITY FORECASTING METHODOLOGY	5-1
5.1.1	Introduction	5-1
5.1.2	Price Influences	5-2
5.2	HISTORIC PROFITABILITY ANALYSIS	5-3
5.2.1	Historic Price-Setting Mechanism	5-3
5.2.2	Methanol Price History	5-4
5.2.3	U.S. Profitability History	5-9
5.2.4	West European Profitability History	5-10
5.8	West European Methanol Margin History	5-11
5.3	PROFITABILITY PROJECTIONS	5-13
5.3.1	Price Setting Mechanism	5-13
5.3.2	Profitability Analysis	5-16
5.4	METHANOL PRICE FORECASTS	5-18
5.4.1	Asian and USGC Pricing	5-19
6	Technology Review	6-1
6.1	METHANOL PROPERTIES	6-1
6.1.1	Methanol Physical Properties	6-1
6.1.2	Methanol Specifications - Product Quality	6-1
6.2	BASIC CHEMISTRY	6-4
6.3	METHANOL TECHNOLOGY OVERVIEW	6-7
6.3.1	Gas-Based Methanol Processes	6-7
6.3.2	Coal/Petroleum Coke Gasification Based Processes	6-12
6.3.3	Methanol/Ammonia Dual Process	6-13
6.4	METHANOL LICENSOR OVERVIEW	6-15
6.4.1	Market Share	6-15
6.4.2	Large Scale (5 000 ton Per Day) Experience	6-16
6.5	TECHNOLOGY DEVELOPMENTS	6-18
6.5.1	Introduction	6-18
6.5.2	Recent Selected Patents	6-18
6.5.3	Direct Methanol Synthesis from Carbon Dioxide	6-31
6.5.4	Carbon Dioxide Reforming	6-32
6.5.5	Selective Liquid-Phase Direct Oxidation of Methane to Methanol	6-33
6.5.6	Biomethanol	6-35
6.5.7	Biomass Gasification	6-35
6.5.8	Polygeneration from Coal	6-40
6.5.9	Liquid-Phase Methanol Technology	6-41
7	Delivered Cost Competitiveness	7-1

7.1	BACKGROUND	7-1
7.1.1	Introduction.....	7-1
7.1.2	Cost of Production Terminology.....	7-1
7.1.3	Location Factors.....	7-2
7.1.4	Other Cost Elements	7-3
7.2	BASIS AND COVERAGE	7-4
7.2.1	Location and Market Coverage.....	7-4
7.3	FEEDSTOCK PRICES	7-5
7.3.1	Gas Prices.....	7-5
7.3.2	Coal Price in China	7-7
7.3.3	Vacuum Residue Oil Value.....	7-7
7.4	SHIPPING COSTS	7-8
7.5	TARIFF.....	7-11
7.6	DELIVERED COST COMPETITIVENESS COMPARISON.....	7-12
7.6.1	Plants Considered.....	7-12
7.6.2	Results.....	7-12

Appendix	Page
A Macro-Economic Assumptions	A-1
B Methanol Capacity Listing.....	B-1
C Methanol Supply/Demand Balance	C-2
D Major Methanol Consumers	D-1
E Methanol Price History and Forecasts	E-1
F Technology Review.....	F-1
G Cost of Production for a New Methanol Plant	G-1
H Methanol Delivered Cash Costs.....	H-1

Figure	Page
3.1 U.S. Gasoil, Fuel Oil and Gas Prices	3-6
3.2 Methanol to Gasoline Price Ratio	3-7
3.3 Methanol Demand in China per Application	3-8
3.4 Typical Value to End-Use Curve for Methanol	3-9
3.5 Typical Value to End-Use Curve for Methanol	3-9
3.6 Gas Production in the U.S.	3-11
3.7 U.S Net LNG Imports	3-12
3.8 Methanol Delivered Cost Competitiveness to USGC, 2012	3-13
3.9 Methanol Conversion Olefins Facilities in China	3-14
3.10 Light Olefins Cost of Production	3-15
4.1 End-Use Consumption Drivers	4-2
4.2 Trade Considerations	4-4
4.3 Methanol Consumption by Application, 2011	4-5
4.4 Global Methanol Consumption by End-Use, 2011–2030	4-6
4.5 Global Methanol Demand by Region, 2011	4-7
4.6 Global Methanol Consumption, 2000–2030	4-7
4.7 Formaldehyde Consumption by Application, 2011	4-8
4.8 Acetic Acid Consumption by End-Use, 2011	4-10
4.9 Global Biodiesel Production	4-21
4.10 Global Methanol Capacity Breakdown, 2011–2030	4-32
4.11 Top Ten Methanol Producers, 2011	4-35
4.12 Global Methanol Supply/Demand	4-41
4.13 Global Net Trade	4-43
4.14 Global Net Trade Flows	4-43
4.15 Chinese Methanol Demand by Application, 2011	4-50
5.1 Data Flow within ChemSystems Simulator	5-1
5.2 Declining Effect of U.S. Natural Gas on Methanol Price	5-3
5.3 Global Methanol Pricing	5-4
5.4 U.S. Methanol Price History	5-8
5.5 West European Methanol Price History	5-8
5.6 Differential between West European and U.S. Contract Methanol Prices	5-9
5.7 U.S. Methanol Margin History	5-10
5.8 West European Methanol Margin History	5-11
5.9 Methanol:Premium Gasoline Price Ratio	5-14
5.10 Methanol Price Setting Mechanism	5-15
5.11 Methanol (Gas Based Plant) Cash Cost Margins	5-16
5.12 Return on Investment Forecast	5-17

5.13	Methanol Price Forecasts	5-18
5.14	West European Methanol Price Forecasts.....	5-19
6.1	Selected Methanol Reformer Options	6-8
6.2	Aerial View of SMR Methanol Plant (DPT Technology).....	6-9
6.3	Flow Scheme for the Production of Methanol from Coal or Petroleum Coke	6-13
6.4	Dual Process of Ammonia/Methanol	6-13
6.5	Ammonia and Methanol Conventional Processes.....	6-14
6.6	Methanol Technology Licensors.....	6-15
6.7	Methanol Licensor Market Share in 2012(1)	6-16
6.8	Simplified Flow Diagram Lurgi GmbH Patent (US2012/0129958 A1)	6-19
6.9	Simplified Block Diagram Methanol Casale Patent (EP 2,450,100 A1)	6-21
6.10	Simplified Flow Diagram Methanol Casale Patent (EP 1,762, 555 A1).....	6-23
6.11	Simplified Flow Diagram Methanol Casale Patent (EP 1,762,555 A1).....	6-28
6.12	Schematic of Flow Diagram Haldor Topsøe Patent (U.S. 2006/0235090 A1)	6-30
6.13	Simplified Flow Diagram UOP Patent (U.S. 7,288,684 B1)	6-34
6.14	Process Schematic - CHOREN Syngas Production from Biomass.....	6-37
6.15	LPMEOH™ Facility Integration into Existing Facilities.....	6-43
6.16	“LPMEOH™ Facility” Simplified Process Flow Diagram	6-44
6.17	LPMEOH™ Reactor Schematic	6-45
7.1	Methanol Delivered Cost to Western Europe (Rotterdam), 2012	7-13
7.2	Methanol Delivered Cost to USGC (Houston), 2012	7-14
7.3	Methanol Delivered Cost to South-East Asia (Singapore), 2012.....	7-15
7.4	Methanol Delivered Cost to North-East Asia (Yokohama), 2012	7-16
A.1	Production Volume of Different Crude Oil Types.....	A-4
A.2	Historical Crude Oil Price.....	A-7
A.3	Real Price of Crude Oil.....	A-10
A.4	Crude Oil Price Scenarios	A-11
A.5	U.S. Natural Gas, Fuel Oil and Gas Oil Prices	A-16
A.6	West European Natural Gas, Fuel Oil, and Gas Oil Prices	A-17
A.7	World Economic Performance.....	A-18
A.8	World Economic Performance and Medium Scenario Outlook.....	A-20
A.9	North American Economic Growth	A-21
A.10	South American Economic Growth	A-22
A.11	West European Economic Growth.....	A-23
A.12	Middle Eastern Economic Growth.....	A-24
A.13	Asia (Ex-Japan and China) Economic Growth	A-25
A.14	Japanese Economic Growth.....	A-26
A.15	Chinese Economic Performance and Outlook	A-27

F.1	Three Main Gasification Processes(1)	F-2
F.2	GE Energy Gasifier	F-6
F.3	Lurgi Dry-Ash Gasifier	F-7
F.4	Shell Gasification Process	F-9
F.5	E-GAS Gasifier	F-10
F.6	Davy Process Technology (DPT) & Johnson Matthey Catalysts (JM) Technology Evolution Timeline.....	F-12
F.7	Johnson Matthey Catalysts Low Pressure Methanol Process	F-14
F.8	ARC Converter	F-16
F.9	Methanol Equilibrium Profile in Quench Converter	F-16
F.10	Toyo Engineering Corporation MRF-Z Converter	F-17
F.11	Temperature Profile of MRF-Z Converter	F-18
F.12	Tube Cooled Converter	F-19
F.13	Methanol Equilibrium Profile in Tube Cooled Converter.....	F-19
F.14	Radial Steam Raising Converter(2)	F-21
F.15	Axial Steam Raising Converter(2)	F-21
F.16	Davy Process Technology Distillation System for Methanol	F-23
F.17	Johnson Matthey Catalysts Leading Concept Methanol Process	F-25
F.18	Johnson Matthey Catalysts AGHR System.....	F-26
F.19	Steam Reformer	F-30
F.20	Davy Process Technology Improved Low Pressure Methanol Process	F-32
F.21	Davy Process Technology Compact Methanol Process	F-34
F.22	Compact Reformer	F-35
F.23	Compact Reformer	F-36
F.24	Davy Process Technology Combined Reforming Process.....	F-38
F.25	SMR and ATR in Combined Reforming DPT Process	F-39
F.26	DPT & JM Combined Reforming with Conventional Steam Methane Reformer Process	F-40
F.27	Davy Process Technology Combined Reforming with GHR and ATR Process.....	F-42
F.28	DPT & JM Gas Heated Reformer plus Autothermal Reformer System	F-43
F.29	Davy Process Technology Series Loop.....	F-48
F.30	Uhde Combined Autothermal Reformer (CAR®)	F-52
F.31	Uhde CAR® based Methanol Plant	F-54
F.32	Uhde 3 and 4 Column Distillation Section.....	F-56
F.33	Uhde Fuel Grade Distillation Section	F-57
F.34	Lurgi MegaMethanol Process Autothermal Reforming	F-63
F.35	Lurgi MegaMethanol Process Combined Reforming	F-64
F.36	Lurgi MegaMethanol Process Flow Diagram Reforming	F-65
F.37	Lurgi MegaMethanol Process Flow Diagram – Methanol Synthesis and Distillation	F-66
F.38	Lurgi Water- and Gas-Cooled Methanol Synthesis Reactor	F-67

F.39 Lurgi Combined Converter Synthesis	F-69
F.40 Flow Scheme of the MITSUBISHI Methanol Process	F-71
F.41 Process Flow Diagram of the MITSUBISHI Methanol Process.....	F-72
F.42 MITSUBISHI Superconverter	F-73
F.43 Haldor Topsøe Methanol Production by One-step Reforming Process	F-78
F.44 Haldor Topsøe Methanol Production by Two-step Reforming Process.....	F-79
F.45 Haldor Topsøe Methanol Production by Autothermal Reforming and Hydrogen Recycle Process	F-81
F.46 Haldor Topsøe Co-production of Methanol Process in Ammonia Plants	F-82
F.47 Methanol Casale M-3000 Methanol Process	F-84
F.48 Methanol Casale IMC Converter	F-85
F.49 Cooling Plate of IMC Converter	F-86
F.50 Methanol Casale M-7000 Methanol Process	F-88

Table	Page
3.1 Summary of MTG Plants	3-4
3.2 MTG Gasoline vs. U.S. Conventional Refinery Gasoline	3-5
4.1 Comparison of Physical Properties	4-22
4.2 Comparison of Gasoline Blending Properties	4-22
4.3 LPG and DME Bottles Comparison.....	4-26
4.4 Methanol Capacity Additions (Excluding China), 2012 Onwards.....	4-32
4.5 Chinese Methanol Capacity Additions, 2012 Onwards	4-33
6.1 Typical Properties of Methanol.....	6-1
6.2 United States Methanol Specifications	6-2
6.3 International Methanol Producers and Consumers Association Methanol Reference	6-3
6.4 Pre-Converter Effects on Methanol Synthesis	6-27
6.5 Effect of Hydrogen Separation Unit on Production Capacity	6-27
7.1 Installation Factors.....	7-2
7.2 2012 Producer Gas Prices	7-6
7.3 Key Parameters for Methanol Shipping.....	7-9
7.4 2012 Shipping Costs to Rotterdam, Houston, Singapore and Yokohama.....	7-10
7.5 Representative Methanol Plants Modelled.....	7-12
A.1 Historic Crude Oil Prices	A-6
A.2 Crude Oil Price Scenarios	A-12
A.3 Economic Growth and Medium Crude Oil Scenario Projections	A-19
B.1 The Development of North American Methanol Capacity, 2000-2012	B-1
B.2 The Development of South American Methanol Capacity, 2000-2012	B-2
B.3 The Development of Chinese Methanol Capacity, 2000-2012	B-3
B.4 The Development of Asian Pacific (excluding China) Methanol Capacity, 2000-2012.....	B-9
B.5 The Development of Central and Eastern European Methanol Capacity, 2000-2012	B-10
B.6 The Development of Western European Methanol Capacity, 2000-2012	B-11
B.7 The Development of African Methanol Capacity, 2000-2012.....	B-12
B.8 The Development of Middle Eastern Methanol Capacity, 2000-2012	B-13
C.1 Global Methanol Supply/Demand Balance.....	C-2
C.2 North America Methanol Supply/Demand Balance.....	C-3
C.3 South America Methanol Supply/Demand Balance.....	C-4
C.4 Western Europe Methanol Supply/Demand Balance.....	C-5
C.5 Central & Eastern Europe Methanol Supply/Demand Balance	C-6
C.6 Middle East Methanol Supply/Demand Balance	C-7
C.7 Africa Methanol Supply/Demand Balance	C-8
C.8 Asia Pacific (excluding China and Japan) Methanol Supply/Demand Balance.....	C-9
C.9 China Methanol Supply/Demand Balance	C-10

C.10	Japan Methanol Supply/Demand Balance.....	C-11
D.1	Major Methanol Consumers - Formaldehyde, 2011	D-1
D.2	Major Methanol Consumers – Acetic Acid, 2011.....	D-9
D.3	Major Methanol Consumers - MTBE 2011	D-10
E.1	Methanol Price History	E-1
F.1	Gasifier Types	F-3
F.2	Gasifier Typical Characteristics(1)	F-3
F.3	Syngas Compositions for Entrained-flow Gasifiers(1)	F-4
F.4	Syngas Compositions for Moving and Fluid-Bed Gasifiers(1).....	F-4
F.5	Syngas Composition for Different Reforming Processes	F-46
F.6	Typical Syngas Compositions Including Coal Gasification	F-49
F.7	Cooling Factors for Methanol Converters.....	F-49
F.8	Typical Process Parameters of Uhde CAR® Configuration	F-52
F.9	Jacobs Summary of Performance of Battery Limit Units	F-59
F.10	Operating and Design Parameters for Pre-Reforming and Autothermal Reforming of Lurgi MegaMethanol Process	F-61
F.11	Operating and Design Parameters for Methanol Converter of Lurgi MegaMethanol Process	F-68
G.1	Cost of Production Process: Steam Methane Reforming Followed by Methanol Synthesis .	G-1
H.1	Delivered Cost to Western Europe (Rotterdam) 2012	H-1
H.2	Delivered Cost to USGC (Houston) 2012.....	H-2
H.3	Delivered Cost to South-East Asia (Singapore) 2012.....	H-3
H.4	Delivered Cost to North-East Asia (Yokohama) 2012.....	H-4