

# CHEMSYSTEMS PERP PROGRAM

## *Renewable Liquids as Steam Cracker Feedstocks*

*PERP 09/10S12*

*October 2010*

Alan J. Nizamoff



44 South Broadway, White Plains, New York 10601, USA

Tel: +1 914 609 0300 Fax: +1 914 609 0399

This Report was prepared by Nexant, Inc ("Nexant") and is part of the ChemSystems Online® suite. 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. 2010. All rights reserved.**

# Contents

---

	Page
<b>1 Executive Summary</b> .....	1
1.1 INTRODUCTION .....	1
1.2 TECHNOLOGY .....	1
1.2.1 Patents .....	1
1.2.2 Product Qualities.....	2
1.2.3 Commercialization.....	3
1.2.4 Steam Cracking of Renewable Naphtha .....	3
1.3 ECONOMIC ANALYSIS .....	7
1.4 COMMERCIAL ANALYSIS.....	8
1.4.1 United States .....	8
1.4.2 Western Europe.....	9
1.4.3 Asia Pacific .....	10
<b>2 Introduction</b> .....	12
<b>3 Technology</b> .....	14
3.1 SYNTROLEUM'S BIO-SYNFINING™ PROCESS.....	14
3.1.1 Status.....	14
3.1.2 Process Description.....	14
3.1.3 Product Qualities.....	23
3.1.4 Commercialization.....	25
3.2 UOP PATENT APPLICATION 2010/0076238.....	25
3.3 STEAM CRACKING OF RENEWABLE NAPHTHA .....	28
3.3.1 Background.....	28
3.3.2 Renewable Naphtha Steam Cracking Yields .....	30
<b>4 Economic Analysis</b> .....	32
4.1 BASIS .....	32
4.1.1 Pricing Basis .....	32
4.1.2 Investment Basis .....	32
4.1.3 Cost of Production Basis.....	33

4.2	ECONOMIC ANALYSIS.....	34
4.2.1	Capacity .....	34
4.2.2	Capital Costs .....	35
4.2.3	Cost of Production .....	35
4.2.4	Sensitivity Analysis .....	40
4.3	CONCLUSIONS.....	45
<b>5</b>	<b>Commercial Analysis</b> .....	<b>47</b>
5.1	APPLICATIONS .....	47
5.2	UNITED STATES .....	48
5.2.1	Consumption .....	48
5.2.2	Supply .....	50
5.2.3	Supply, Demand, and Trade.....	52
5.3	WESTERN EUROPE .....	53
5.3.1	Consumption .....	53
5.3.2	Supply .....	55
5.3.3	Supply, Demand, and Trade.....	56
5.4	ASIA PACIFIC .....	59
5.4.1	Supply .....	62
5.4.2	Supply, Demand, and Trade.....	67
<b>6</b>	<b>References</b> .....	<b>69</b>
	Appendix	Page
<b>A</b>	<b>List of Acronyms and Abbreviations</b> .....	<b>A-1</b>
<b>B</b>	<b>Nexant’s <i>ChemSystems</i> Capital Cost Estimates</b> .....	<b>B-1</b>
<b>C</b>	<b>PERP Program Title Index (2000/2001 – 2009/2010)</b> .....	<b>C-1</b>

Figure	Page
1.1 Comparison of Ethylene Costs of Production.....	7
1.2 United States Ethylene Supply/Demand and Operating Rates .....	9
1.3 Western European Ethylene Supply/Demand and Operating Rates .....	10
1.4 Asia Pacific Ethylene Supply/Demand and Operating Rates .....	11
2.1 Regional Steam Cracker Feedstock Consumption.....	12
3.1 Patent 2008/059434 .....	16
3.2 Patent 2009/0300971 Block Flow Diagram.....	18
3.3 Patent 2010/0043279 Flow Diagram .....	21
3.4 Patent 2010/0076238 Flow Diagram .....	26
4.1 Regional Average and World Scale Capacities of Steam Crackers.....	35
4.2 Sensitivity of Bio-Ethylene Cost Of Production to Severity .....	40
4.3 Sensitivity of Ethylene Cost of Production to Feed Pricing .....	41
4.4 Sensitivity of Ethylene Cost of Production to Propylene Pricing.....	42
4.5 Sensitivity of Ethylene Cost of Production to Butadiene Pricing.....	42
4.6 Sensitivity of Ethylene Cost of Production to Capital Investment .....	44
4.7 Sensitivity of Ethylene Cost of Production To Economy Of Scale .....	45
4.8 Comparison of Ethylene Costs of Production.....	46
5.1 United States Ethylene Consumption, 2009 .....	49
5.2 United States Ethylene Supply/Demand and Operating Rates .....	53
5.3 West European Ethylene Consumption, 2008 .....	55
5.4 Western European Ethylene Supply/Demand and Operating Rates .....	58
5.5 Asia Pacific Ethylene Consumption, 2009 .....	61
5.6 Asia Pacific Ethylene Supply/Demand and Operating Rates .....	68

Table	Page
1.1 Overall Cracking Yields at Moderate Severity .....	6
3.1 Renewable Jet Fuel Iso/Normal Ratio .....	24
3.2 Overall Cracking Yields at Moderate Severity .....	31
4.1 Feedstock and Byproduct Prices .....	32
4.2 Cost of Production for “Green” Ethylene Process: Steam Cracking of F-T Naphtha from Renewable Source .....	37
4.3 Cost of Production for Ethylene Process: Steam Cracking of F-T Naphtha from Gas-to-Liquids Source.....	38
4.4 Cost of Production for Ethylene Process: Steam Cracking of Petroleum-based Naphtha.....	39
5.1 United States Ethylene Capacity.....	51
5.2 United States Ethylene Supply, Demand, and Trade.....	52
5.3 Capacities for Ethylene in Western Europe .....	57
5.4 West European Ethylene Supply, Demand, and Trade.....	58
5.5 Capacities of Ethylene in Asia Pacific.....	65
5.5 (Continued) Capacities of Ethylene in Asia Pacific .....	66
5.6 Asia Pacific Ethylene Supply, Demand, and Trade.....	68