

# THE NEW ECONOMICS OF OCTANE

What Drives the Cost of Octane and Why  
Octane Costs Have Risen Since 2012



A Report By:



T. J. HIGGINS

# Contents

- Foreword..... 1
- 1. Executive Summary ..... 2
- 2. Tracking the Changing Market Value of Octane: 2000–2016 ..... 8
  - 2.1 Changes in the Market Value of Octane Over Time: 2000-2016..... 8
  - 2.2 Why the Premium/Regular Price Differential Increases from Refinery to Retail ..... 14
- 3. U.S. Octane Market Fundamentals: The Changing Landscape ..... 15
  - 3.1 Gasoline Supply and Demand..... 16
  - 3.3 Production of Crude Oil, Condensate, NGL, and Natural Gas ..... 22
  - 3.4 Composition of the U.S. Refinery Crude Oil Slate ..... 25
  - 3.5 Prices of Crude Oil, Gasoline, LPGs, and Natural Gas ..... 26
  - 3.6 Refining Capacity and Capacity Utilization ..... 28
- 4. The Refining Economics of Octane ..... 30
  - 4.1 Gasoline Blending to Meet Octane and Other Specifications: The Basics ..... 30
  - 4.2 The Primary Gasoline Blendstocks and Their Contribution to Overall Pool Octane ..... 31
  - 4.3 Overview of Catalytic Reforming..... 33
  - 4.4 A Word About Alkylate ..... 38
  - 4.5 A Word About FCC Naphtha ..... 38
  - 4.6 Additional Refining Costs Associated With Premium Gasoline ..... 39
  - 4.7 Downstream Costs Associated With Premium Gasoline ..... 39
- 5. The New Economics of Octane: Supply-Driven and Demand-Driven Octane Markets ..... 40
  - 5.1 The Changing Relationship Between Octane Supply Capability and Octane Demand ..... 41
  - 5.2 Supply-Driven and Demand-Driven Octane Markets..... 41
  - 5.3 Estimated Relative Magnitudes of the Supply and Demand Influences on the Market Value of Octane..... 44
  - 5.4 Factors Affecting the Refining Sector’s Cost and Capability to Produce Octane ..... 45
  - 5.5 Factors Affecting the Market Demand for Octane..... 47
  - 5.6 Additional Comment ..... 49
- 6. The Octane Market and Premium/Regular Price Differentials, 2016-2021..... 50
  - 6.1 Where Might the Market Value of Octane Head?..... 51

6.2 Outlook for Crude Oil, Natural Gas, and LPG Prices.....	52
6.3 Outlook for PADD 3’s Production of Hydrocarbon Gasoline and Octane .....	53
6.4 The Refining Sector’s Capability for Producing Octane .....	56
6.5 Perspective on the Near-Term Market Value of Octane.....	57
7. International Gasoline and Octane Markets: Implication for U.S. Octane Outlook .....	59
7.1 Gasoline Demand and Trade Flow .....	60
7.2 Crude Oil, NGL, and Natural Gas Price Relationships .....	62
7.3 Regional Octane Market Trends .....	62
7.3.1 Europe .....	62
7.3.2 Latin America.....	63
7.3.3 Russia/CIS.....	65
7.3.4 Asia Pacific.....	66
7.3.5 Middle East .....	67
7.3.6 Africa.....	68
7.4 Summary of Regional Trends in Hydrocarbon Gasoline Octane.....	69
Appendix A / Glossary .....	70
Abbreviations.....	70
Definitions .....	72
Octane-Related Terms .....	72
U.S. Gasoline Grades .....	72
U.S. Gasoline Types and BOBs .....	72
International Gasoline Grades.....	73
Octane Economics .....	73
Appendix B .....	74
Recent Changes in the Composition and Properties of the U.S. Refinery Crude Slate and Hydrocarbon Exports .....	74
B.1 Net Exports of Light Hydrocarbons.....	74
B.2 Imports of Crude Oil .....	74
B.3 Key Properties of the Aggregate U.S. and PADD 3 Crude Slates in 2010 and 2015.....	74
Appendix C .....	78
The Prospective Effect of Turbocharging on Domestic Demand for Octane .....	78
Endnotes.....	81

# List of Exhibits

- Exhibit 1.1: Average Annual Premium/Regular Spot Price Deltas and Regular Gasoline Prices (Gulf Coast)
- Exhibit 1.2: U.S. Demand for Hydrocarbon Gasoline and Oxygenates: 2000-2016 (MM b/d)
- Exhibit 1.3: U.S. Imports and Exports of Gasoline and Gasoline Blendstocks: 2000-2016 (K b/d)
- Exhibit 1.4: Estimated Hydrocarbon Octane and Octane Boost from Oxygenates in U.S. Refinery-Produced Gasoline: 2000-2016
- Exhibit 1.5: PADD 3 Reformer Capacity Utilization, Capacity, and Throughput: 2000-2016 (MM b/d)
- Exhibit 1.6: A Supply/Demand Framework for Considering the Market Value of Octane
- Exhibit 1.7: Estimated Allocation of the Premium/Regular Price Delta to Supply and Demand Factors – PADD 3, Summer Season 2010-2016
- Exhibit 2.1: Gulf Coast Average Annual Premium/Regular Spot Price Deltas and Regular Gasoline and Brent Spot Prices
- Exhibit 2.2: Gulf Coast Average Quarterly Premium/Regular Spot Price Deltas and Regular Gasoline and Brent Spot Prices
- Exhibit 2.3: Gulf Coast Annual Spot, Rack & Retail Grade Deltas and Spot, Rack, and Retail Regular Gasoline Prices
- Exhibit 2.4: Gulf Coast Quarterly Spot, Rack & Retail Grade Deltas and Spot, Rack, and Retail Regular Gasoline Prices
- Exhibit 2.5: Gulf Coast Annual Retail Grade Deltas and Retail and Rack Regular Gasoline Prices
- Exhibit 2.6: Annual Average Rack Premium/Regular Grade Price Deltas, by Region
- Exhibit 2.7: Annual Average Retail Premium/Regular Grade Price Deltas, by Region
- Exhibit 3.1: U.S. Demand for Hydrocarbon Gasoline and Oxygenates: 2000-2016 (MM b/d)
- Exhibit 3.2: U.S. Imports and Exports of Gasoline and Gasoline Blendstocks: 2000-2016 (K b/d)
- Exhibit 3.3: PADD 3 Finished Gasoline Supply, Hydrocarbon Gasoline Production, and Oxygenate Blending: 2000-2016 (K b/d)
- Exhibit 3.4: Estimated Hydrocarbon Octane and Octane Boost from Oxygenates in U.S. Refinery-Produced Gasoline: 2000-2016
- Exhibit 3.5: MTBE and Ethanol in the U.S. Gasoline Pool: 2000-2016 (K b/d)
- Exhibit 3.6: High-Octane Share of the U.S. Gasoline Pool: 2000-2016
- Exhibit 3.7: U.S. Crude Oil Production By Region: 2007-2016 (MM b/d)
- Exhibit 3.8: Quarterly U.S. Tight Oil Production from Selected Formations: 2007-2016 (MM b/d)
- Exhibit 3.9: Annual Production of Dry Natural Gas (Bcf/d) and Natural Gas Plant Liquids, Lease Condensate, and Tight Oil (MM b/d): 2000-2016
- Exhibit 3.10: Estimated U.S. Production of Crude Oil and Condensate, by API Gravity: 2010-2016 (MM b/d)
- Exhibit 3.11: Gulf Coast Crude Oil Acquisition Costs and Spot Prices for Regular Gasoline and LPGs, and Henry Hub Spot Prices for Natural Gas: 2000-2016
- Exhibit 3.12: Spot Prices for Regular Gasoline and LPGs, Gulf Coast: 2000-2016 (\$/gal)
- Exhibit 3.13: Spot LPG Prices Relative to Spot Regular Gasoline Prices, U.S. Gulf Coast: 2000-2016
- Exhibit 3.14: PADD 3 Seasonal Crude Oil Distillation Capacity Utilization, Operating Capacity, and Throughput: 2000-2016 (MM b/d)
- Exhibit 3.15: PADD 3 Seasonal Reformer Capacity Utilization, Capacity, and Throughput: 2000-2016 (MM b/d)
- Exhibit 4.1: Primary Gasoline Blendstocks: Hydrocarbons and Oxygenates
- Exhibit 4.2: Composition of the U.S. Gasoline Pool: 2005, 2010, and 2014
- Exhibit 4.3: Octane Contributions to the U.S. Gasoline Pool, by Blendstock: 2005, 2010, and 2014
- Exhibit 4.4: Reformer Inputs and Outputs

- Exhibit 4.5: Reformer Yields as Functions of Severity (Illustrative)
- Exhibit 4.6: Reformate Yield as a Function of Feed Quality (Illustrative)
- Exhibit 4.7: Seasonal U.S. Reforming Capacity Utilization, Capacity, and Throughput: 2010-2016
- Exhibit 5.1: Illustrative Supply-Demand Framework for Considering the Market Value of Octane
- Exhibit 5.2: Estimated Allocation of the Premium/Regular Price Delta for PADD 3 to Supply and Demand Factors, Summer Season 2010-2016
- Exhibit 5.3: PADD 3 Production of Hydrocarbon Gasoline, by Type, 2000-2016
- Exhibit 5.4: PADD 3 Production of Hydrocarbon Octane Barrels and Pool Octane of Hydrocarbon Gasoline, 2000-2016
- Exhibit 6.1: World Bank and EIA Price Forecasts: 2015-2021
- Exhibit 6.2: PADD 3 Production of Hydrocarbon Gasoline for the Domestic and Export Markets: 2015-2021
- Exhibit 6.3: Projected PADD 3 Pool Octane and Production of Octane-Barrels for Hydrocarbon Gasoline: 2015-2021
- Exhibit 7.1: Europe and OECD Asia Gasoline Demand: 2014-2021 (K b/d) (Includes Oxygenates)
- Exhibit 7.2: Non-OECD Gasoline Demand: 2014-2021 (K b/d) (Includes Oxygenates, Excludes Non-OECD Europe)
- Exhibit 7.3: U.S. Gasoline Exports to Latin America: 2005-2021 (K b/d) (Includes Oxygenates, Includes Mexico)
- Exhibit 7.4: Octane in the European Market: 2014-2021, RON
- Exhibit 7.5: Octane in the Latin America Market (Including Mexico): 2014-2021, RON
- Exhibit 7.6: Octane in the Russian/CIS Market: 2014-2021, RON
- Exhibit 7.7: Octane in the Asian (ex-China) Market: 2014-2021, RON
- Exhibit 7.8: Octane in the Chinese Market: 2014-2021, RON
- Exhibit 7.9: Octane in the Middle Eastern Market: 2014-2021, RON
- Exhibit 7.10: Octane in the African Market: 2014-2021, RON
- Exhibit 7.11: Regional Trends in Refinery-Produced Octane: 2014-2021, RON
- Exhibit B.1: U.S. Net Exports of LPGs: 2000-2016 (K b/d)
- Exhibit B.2: U.S. Net Exports of Pentanes, Naphthas, and Condensate: 2000-2016 (K b/d)
- Exhibit B.3: Share of U.S. Imported Crude Oil by Supplying Region, and Total Crude Oil Imports and U.S Production: 2000-2016
- Exhibit B.4: Share of U.S. Imported Crude Oil by API Gravity: 2000-2016
- Exhibit B.5: Estimated Volume, Fractions, and Properties of the Composite Crude Slate, United States: 2010 and 2015
- Exhibit B.6: Estimated Volume, Fractions, and Properties of the Composite Crude Slate, PADD 3: 2010 and 2015
- Exhibit C-1: U.S. Premium Share, Retail Premium/Regular Price Delta, and Retail Price of Premium and Regular Gasoline: 2000-2016
- Exhibit C-2: Turbocharged Vehicle's Share of: New Vehicle Sales, Vehicle Stock, VMT, and Gasoline Use: 2009-2025
- Exhibit C-3: Projected Premium Market Share under Alternative Assumptions for Turbocharged Vehicles' Fueling with Premium Gasoline