

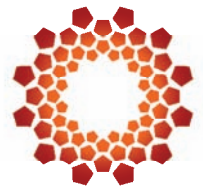
2025 Unconventional Gas Outlook

The Next Wave?

Draft

August 2010

CORE
ENERGY
GROUP



Terms and Conditions

This document has been prepared by Core Energy Group Pty Limited (“Core”) for the sole purpose of providing the Reader with access to strategic level research and analysis relating to the outlook for Unconventional Gas in Australia.

This document does not purport to contain all the information that a particular party may require. The information contained in this document may not be appropriate for all persons and it is not possible for Core to have regard to the investment objectives, financial situation and particular needs of each party who reads or uses this document.

Core makes no representation or warranty as to the accuracy, reliability, completeness or suitability of the information contained within this document. Core, its Directors, employees, agents and consultants accept no liability (including liability to any person by reason of negligence or negligent misstatement) for any statements, opinions, information or matter (expressed or implied) arising out of the information contained within this document, except in so far as liability under statute cannot be excluded.

© Core Energy Group – All material in this document is subject to copyright under the Copyright Act 1968 (Commonwealth) and international law and permission to use the information must be obtained in advance and in writing from Core.

Table of Contents

| | |
|---|----|
| Terms and Conditions | i |
| List of Tables..... | v |
| List of Figures | vi |
| 1. Introduction and Scope..... | 1 |
| 1.1 Introduction | 1 |
| 1.2 Scope | 1 |
| 2. Executive Summary..... | 2 |
| 2.1 Introduction | 2 |
| 2.2 International Experience..... | 2 |
| 2.3 Technical Issues | 3 |
| 2.4 Unconventional Gas Product Markets | 4 |
| 2.5 Price Outlook | 6 |
| 2.6 Future Supply..... | 6 |
| 2.7 Regulatory and Legal Issues | 9 |
| 2.8 Policy..... | 9 |
| 3. Overview of Global Unconventional Gas | 10 |
| 3.1 The Role of Gas in the International Energy Mix | 10 |
| 3.2 International Gas Demand Drivers..... | 10 |
| 3.3 International Gas Demand and Supply..... | 14 |
| 3.4 International Unconventional Gas Trends | 18 |
| 3.5 Status of International Unconventional Gas Activity | 21 |
| 3.6 Status of Gas to Liquids Activity | 22 |
| 4. Technical Issues | 24 |
| 4.1 Shale Gas..... | 24 |
| 4.2 Tight Gas | 34 |
| 4.3 Advances in Shale and Tight Gas Technology | 38 |
| 4.4 UCG..... | 39 |
| 4.5 CSG | 43 |
| 5. Overview of UNCG Activity in Australia..... | 51 |
| 5.1 Current State of Play..... | 51 |
| 5.2 Australian Activity Overview | 53 |
| 5.3 State by State Analysis | 55 |
| 6. Unconventional Gas Reserves and Resources | 61 |
| 6.1 Australian Overview..... | 61 |

| | | |
|------|--|-----|
| 6.2 | Eastern Australia | 62 |
| 6.3 | Western Australia | 68 |
| 6.4 | Northern Australia | 71 |
| 7. | Domestic Gas Market Outlook | 75 |
| 7.1 | Introduction | 75 |
| 7.2 | Eastern Australia Domestic Gas | 76 |
| 7.3 | Western Australia | 88 |
| 7.4 | Northern Australia | 93 |
| 8. | LNG Market Outlook | 94 |
| 8.1 | Introduction | 94 |
| 8.2 | Asian LNG Demand | 95 |
| 8.3 | Asian LNG Contracted Volumes | 95 |
| 8.4 | Asian LNG Likely Contracts and Extensions | 96 |
| 8.5 | Unfulfilled Asian LNG Demand | 97 |
| 8.6 | Potential LNG Demand Reduction | 99 |
| 9. | Australian Liquids Market Outlook | 100 |
| 9.1 | Introduction | 100 |
| 9.2 | Oil Demand Outlook | 100 |
| 9.3 | Oil Supply Outlook | 101 |
| 9.4 | Imported Crude and Petroleum Products | 101 |
| 9.5 | Domestic Crude Production Outlook | 103 |
| 9.6 | Liquids Standards | 105 |
| 9.7 | Scope for GTL Production | 107 |
| 10. | Development and Production Cost Analysis | 109 |
| 10.1 | CSG | 110 |
| 10.2 | Shale and Tight Gas | 111 |
| 10.3 | UCG | 112 |
| 11. | Regulatory / Legal Issues | 113 |
| 11.1 | Overlapping Tenure | 113 |
| 11.2 | Water Management | 114 |
| 11.3 | Carbon Emissions | 115 |
| 11.4 | Subsidence and Fracturing | 115 |
| 12. | Gas Price Outlook | 116 |
| 12.1 | Introduction | 116 |
| 12.2 | Current Price Analysis – Eastern Australia | 117 |
| 12.3 | Projected Prices – Eastern Australia | 119 |
| 12.4 | Summary – Eastern Australia | 126 |

| | | |
|------|--|-----|
| 12.5 | Current Supply Analysis – Western Australia..... | 127 |
| 12.6 | Current Supply Analysis – Northern Australia | 129 |
| 13. | Economics of Unconventional Gas | 130 |
| 13.1 | Tight, Shale and CSG | 130 |
| 13.2 | UCG..... | 140 |
| 14. | Future Supply Scenarios..... | 145 |
| 14.1 | Eastern Australia | 145 |
| 14.2 | Western Australia | 165 |
| 14.3 | Northern Australia..... | 170 |
| 15. | Transaction Market Considerations | 171 |
| 15.1 | Transaction Activity..... | 171 |
| 15.2 | Study Findings | 171 |
| 16. | Industry Development Policy..... | 173 |
| 16.1 | Policy Drivers | 173 |
| 16.2 | International Gas Policy..... | 173 |
| 16.3 | Australian Gas Policy..... | 174 |
| 17. | Value Add Potential | 175 |
| 18. | References | 176 |
| 19. | Glossary of Terms | 182 |
| 19.1 | Acronyms..... | 182 |
| 19.2 | Glossary..... | 185 |

Attachment 1: Technical Issues

Attachment 2: Australian Acreage

Attachment 3: Australian Domestic Gas Demand Methodology

Attachment 4: Gas to Liquids Technology

Attachment 5: Liquefied Natural Gas

Attachment 6: Unconventional Gas Economics

Attachment 7: Transactions

List of Tables and Figures

List of Tables

| | |
|---|----|
| Table 3.1: Land and Water Management Issues..... | 13 |
| Table 3.2: Gas Consumption for 2009..... | 15 |
| Table 4.1: Geological Terms..... | 26 |
| Table 4.2: Specific Measures..... | 27 |
| Table 4.3: Comparison of Select US Shale Gas Plays..... | 27 |
| Table 4.4: Key Terms and Concept..... | 28 |
| Table 4.5: Evaluation..... | 29 |
| Table 4.6: Comparison of Select North America Tight Gas Plays..... | 35 |
| Table 4.7: Technological Advances in Shale and Tight Gas..... | 38 |
| Table 4.8: Productivity Gains in Shale and Tight Gas..... | 39 |
| Table 4.9: Comparison of Select UCG Projects..... | 41 |
| Table 4.10: CSG – Key Terms and Variables..... | 44 |
| Table 4.11: CSG – Australian Plays and US Analogues..... | 45 |
| Table 6.1: Overview of CSG Projects in Eastern Australia..... | 62 |
| Table 6.2: Overview of Shale and Tight Gas Projects in Eastern Australia..... | 64 |
| Table 6.3: Overview of UCG projects in Eastern Australia..... | 64 |
| Table 6.4: Contracted and Uncontracted Eastern Australian Resources..... | 67 |
| Table 6.5: Gas Source versus Potential Market..... | 67 |
| Table 6.6: Gas Resources versus Potential Market..... | 68 |
| Table 6.7 Overview of CSG Projects in Western Australia..... | 68 |
| Table 6.8: Overview of Shale and Tight Gas Projects in Western Australia..... | 68 |
| Table 6.9: Overview of UCG and GTL Projects in Western Australia..... | 69 |
| Table 6.10: Contracted and Uncontracted Western Australian Resources..... | 71 |
| Table 6.11: Gas Resources versus Potential Market..... | 71 |
| Table 6.12: Overview of CSG Projects in Northern Australia..... | 72 |
| Table 6.13: Overview of UCG and GTL Projects in Northern Australia..... | 72 |
| Table 6.14: Contracted and Uncontracted Northern Australian Resources..... | 73 |
| Table 6.15: Gas Resources versus Potential Market..... | 74 |
| Table 7.1: Current Coal Fired Generation in New South Wales and the ACT..... | 81 |
| Table 7.2: Current Coal Fired Generation in Queensland..... | 83 |

| | |
|---|-----|
| Table 7.3: Current Coal Fired Generation in South Australia..... | 84 |
| Table 7.4: Current Coal Fired Generation in Victoria..... | 86 |
| Table 7.5: Current Coal Fired Generation in Western Australia..... | 92 |
| Table 9.1: Australia’s Oil and Liquids Consumption Make Up – 2009..... | 101 |
| Table 10.1: Development – CSG..... | 110 |
| Table 10.2: Development – Shale and Tight Gas..... | 111 |
| Table 10.3: Development – UCG..... | 112 |
| Table 12.1: Eastern Australian Current Delivered Prices..... | 119 |
| Table 12.2: 2015-17 Prices - Mainland Capital Cities, in 2010 Dollar Terms..... | 126 |
| Table 12.3: Western Australian Gas Pricing..... | 128 |
| Table 13.1: Primary Cost Influences..... | 131 |
| Table 13.2: Primary Revenue Influences..... | 131 |
| Table 13.3: Reserve/ Resource and Production Influences..... | 131 |
| Table 13.4: Guide to Shale, Tight, CBM Gas Supply Cost..... | 133 |
| Table 13.5: Drilling and Completion Costs..... | 133 |
| Table 13.6: UNCG Production Costs..... | 134 |
| Table 13.7: Australian Shale, CSG, Tight Gas Methodology..... | 137 |
| Table 13.8: Australian Shale Gas Economics – Reference Case Assumptions..... | 138 |
| Table 13.9: Supply Cost Comparison..... | 138 |
| Table 13.10: NPV Comparison..... | 139 |
| Table 13.11: Australian UCG Methodology..... | 141 |
| Table 13.12: Australian UCG Economics – Reference Case Assumptions..... | 142 |
| Table 14.1: Likely Supply Sources – Victoria..... | 150 |
| Table 14.2: Potential Supply Sources – NSW and ACT..... | 155 |
| Table 14.3: Potential Supply Sources – SA..... | 159 |
| Table 14.4: Likely Supply Sources – Western Australia..... | 170 |
| Table 16.1: International Gas Policy..... | 174 |
| Table 16.2: Australian Gas Policy..... | 174 |

List of Figures

| | |
|---|---|
| Figure 2.1: Henry Hub Price (Historical and Projected)..... | 3 |
| Figure 2.2: Unconventional Gas Product Markets..... | 4 |
| Figure 2.3: Potential Asian LNG Market Based on Likely Supply – By Country..... | 5 |
| Figure 2.4: Uncontracted Reference Demand in Eastern Australia..... | 7 |

| | |
|--|----|
| Figure 2.5: Unfulfilled Demand in Eastern Australia after Known Contracts and Probable Supply..... | 7 |
| Figure 2.6: Unfulfilled Reference Gas Demand – WA – Firm Supply..... | 8 |
| Figure 2.7: Remaining Unfulfilled Market – Western Australia..... | 8 |
| Figure 3.1: World Marketed Energy Use by Fuel Type..... | 10 |
| Figure 3.2: Source of Greenhouse Gas Emissions..... | 13 |
| Figure 3.3: International Gas Consumption..... | 14 |
| Figure 3.4: World Proved Gas Reserves as at end 2009..... | 15 |
| Figure 3.5: World Gas Production 2009..... | 16 |
| Figure 3.6: Change in Supply Mix..... | 16 |
| Figure 3.7: Pipeline and LNG Flows..... | 17 |
| Figure 3.8: Trend in International Gas Trade..... | 17 |
| Figure 3.9: Growth of Unconventional Gas in the US..... | 18 |
| Figure 3.10: Estimated Unconventional Gas in Place..... | 18 |
| Figure 3.11: Henry Hub Price (Historical and Projected)..... | 19 |
| Figure 3.12: US – Sources of Supply versus Time..... | 20 |
| Figure 3.13: World Unconventional Gas Activity – Shale, Tight and CSG/CBM..... | 21 |
| Figure 3.14: World Unconventional Gas Activity – Underground Coal Gasification..... | 22 |
| Figure 3.15: World GTL Activity..... | 23 |
| Figure 4.1: Shale Outcrop – Alberta..... | 25 |
| Figure 4.2: Shale Gas Drilling..... | 29 |
| Figure 4.3: Steps in Horizontal Drilling..... | 30 |
| Figure 4.4: Hydraulic Fracturing..... | 31 |
| Figure 4.5: Multi-Stage Fracking..... | 32 |
| Figure 4.6: Microseismic Imaging of a Multi-stage Frac..... | 32 |
| Figure 4.7: Barnett Shale Profile..... | 33 |
| Figure 4.8: Haynesville Shale Profile..... | 33 |
| Figure 4.9: Fayetteville Shale Profile..... | 34 |
| Figure 4.10: Tight Gas Exploration Process..... | 35 |
| Figure 4.11: Colony Wash Profile..... | 37 |
| Figure 4.12: Granite Wash Profile..... | 37 |
| Figure 4.13: UCG Development..... | 42 |
| Figure 4.14: UCG Development Schematic..... | 42 |
| Figure 4.15: Cleats..... | 44 |
| Figure 4.16: CSG Development..... | 47 |

| | |
|---|----|
| Figure 4.17: CSG versus Conventional Gas Production..... | 48 |
| Figure 4.18: Washakie Basin, Wyoming..... | 49 |
| Figure 4.19: Horseshoe Canyon, Alberta - Decline Profile..... | 50 |
| Figure 4.20: Corbett Mannville, Alberta – Production Profile..... | 50 |
| Figure 4.21: Horseshoe Canyon, Alberta – EUR by Well..... | 50 |
| Figure 5.1: Australian Gas Production History and Outlook..... | 52 |
| Figure 5.2: Australian 2P Reserves. | 52 |
| Figure 5.3: Australian Reserves and Resources. | 53 |
| Figure 5.4: Australian Unconventional Gas Activity. | 54 |
| Figure 5.5: Unconventional Gas Make –Up – New South Wales..... | 55 |
| Figure 5.6: Unconventional Gas Overview – NSW and ACT..... | 55 |
| Figure 5.7: Unconventional Gas Make –Up - Queensland. | 56 |
| Figure 5.8: Unconventional Gas Overview – Queensland. | 56 |
| Figure 5.9: Unconventional Gas Make –Up – South Australia. | 57 |
| Figure 5.10: Unconventional Gas Overview – SA..... | 57 |
| Figure 5.11: Unconventional Gas Make –Up – Victoria..... | 58 |
| Figure 5.12: Unconventional Gas Overview – VIC..... | 58 |
| Figure 5.13: Unconventional Gas Make –Up – Western Australia. | 59 |
| Figure 5.14: Unconventional Gas Overview – WA. | 59 |
| Figure 5.15: Unconventional Gas Overview – NT..... | 60 |
| Figure 6.1: Australian 2P Reserves. | 61 |
| Figure 6.2: Australian Unconventional Resource Estimates..... | 62 |
| Figure 6.2: Eastern Australian 2P Reserves. | 65 |
| Figure 6.3: Eastern Australian Reserves and Resources..... | 66 |
| Figure 6.4: Eastern Australian Total Reserves and Resources by Source. | 66 |
| Figure 6.5: Western Australian Reserves and Resources. | 70 |
| Figure 6.6: Western Australian Total Reserves and Resources by Source..... | 70 |
| Figure 6.7: Northern Australia Reserves and Resources..... | 73 |
| Figure 7.1: Australian Domestic Gas Markets..... | 76 |
| Figure 7.2: Eastern Australian Domestic Gas Demand Scenarios..... | 77 |
| Figure 7.3: Eastern Australia Domestic Gas Contract Profile and Demand..... | 77 |
| Figure 7.4: Eastern Australia Uncontracted Domestic Gas Demand..... | 78 |
| Figure 7.5: The Impact of CPRS on Gas Demand for Power Generation..... | 79 |
| Figure 7.6: New South Wales and ACT – Reference Domestic Gas Demand..... | 81 |

| | |
|---|-----|
| Figure 7.7: New South Wales and ACT – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. ... | 82 |
| Figure 7.8: Queensland – Reference Domestic Gas Demand. | 82 |
| Figure 7.9: Queensland – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 83 |
| Figure 7.10: South Australia – Reference Domestic Gas Demand. | 84 |
| Figure 7.11: South Australia – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 85 |
| Figure 7.12: Victoria – Reference Domestic Gas Demand. | 85 |
| Figure 7.13: Victoria – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 86 |
| Figure 7.14: Tasmania – Reference Domestic Gas Demand. | 87 |
| Figure 7.15: Tasmania – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 87 |
| Figure 7.16: Unfulfilled Reference Domestic Gas Demand – Total Eastern Australia. | 87 |
| Figure 7.17: Western Australia Domestic Gas Demand. | 88 |
| Figure 7.18: Western Australia Domestic Gas Contract and Firm Supply Profile and Reference Demand. | 89 |
| Figure 7.19: Western Australia Uncontracted Reference Domestic Gas Demand. | 89 |
| Figure 7.20: Variability in Gas Powered Generation – Western Australia. | 90 |
| Figure 7.21: Western Australia – Reference Domestic Gas Demand. | 92 |
| Figure 8.1: LNG Demand in Asia. | 95 |
| Figure 8.2: LNG Contract Profile – Total Asia. | 96 |
| Figure 8.3: LNG Contract Profile Including Likely Supply – Total Asia. | 97 |
| Figure 8.4: Unfulfilled LNG Demand Based on Firm Contracts Only – Total Asia. | 97 |
| Figure 8.5: LNG Uncontracted Demand Considering Likely Contracts – Total Asia. | 98 |
| Figure 8.6: Potential Asian LNG Market. | 98 |
| Figure 8.7: Potential Asian LNG Market Based on Likely Supply – By Country. | 98 |
| Figure 9.1: Imports of Crude Oil (2006-07). | 102 |
| Figure 9.2: Imports of Petroleum Products (2006-07). | 103 |
| Figure 9.3: Cooper Basin Oil Production. | 103 |
| Figure 9.4: Gippsland Basin Condensate and Cure Oil Production. | 103 |
| Figure 9.5: NWS Oil Production. | 104 |
| Figure 9.6: Total Australian Oil Demand versus Supply. | 104 |
| Figure 12.1: Current Pricing Structure of the Eastern Region (2009/2010) | 117 |
| Figure 12.2: Transmission Costs. | 118 |
| Figure 12.3: New South Wales and ACT – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 120 |
| Figure 12.4: Current Gas Supply to the New South Wales and ACT Market. | 120 |
| Figure 12.5: Queensland – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 122 |
| Figure 12.6: Current Gas Supply to the Queensland Market. | 122 |

| | |
|---|-----|
| Figure 12.7: South Australia – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 123 |
| Figure 12.8: Current Gas Supply to the South Australian Market. | 124 |
| Figure 12.9: Victoria – Uncontracted Reference Gas Demand Based on Current TOP Level Contracts. | 125 |
| Figure 12.10: Current Gas Supply to the Victorian Market. | 125 |
| Figure 12.11: Western Australia Uncontracted Reference Domestic Gas Demand. | 127 |
| Figure 12.12: Current Gas Supply to the Western Market. | 128 |
| Figure 12.13: Current Gas Supply to the Northern Territory. | 129 |
| Figure 13.1: Unconventional Gas Plays in the United States. | 132 |
| Figure 13.2: Tight Gas Economics. | 135 |
| Figure 13.3: CBM Economics. | 135 |
| Figure 13.4: Shale Gas Economics. | 136 |
| Figure 13.5: Conventional Gas Economics. | 137 |
| Figure 13.6: Assumption Production Curves. | 138 |
| Figure 13.7: Sensitivity Analysis – Opex Changes. | 139 |
| Figure 13.8: Sensitivity Analysis – Capex Changes. | 140 |
| Figure 13.9: Sensitivity Analysis – Gas Price Changes. | 140 |
| Figure 13.10: WTI versus Gasoil. | 142 |
| Figure 13.11: WTI versus Japanese Naphtha. | 142 |
| Figure 13.12: Sensitivity Analysis – Product Price. | 143 |
| Figure 13.13: Sensitivity Analysis – Capital Expenditure. | 143 |
| Figure 13.14: Sensitivity Analysis – Operating Expenditure. | 144 |
| Figure 14.1: Unfulfilled Reference Gas Demand – TAS – TOP and ACQ. | 146 |
| Figure 14.2: Unfulfilled Reference Gas Demand – VIC – TOP and ACQ. | 147 |
| Figure 14.3: Probable and Possible Victorian Supply Sources. | 148 |
| Figure 14.4: Probable Supply Scenario – Victoria. | 149 |
| Figure 14.5: Remaining Unfulfilled Market – Victoria. | 150 |
| Figure 14.6: Unfulfilled Reference Gas Demand – NSW and ACT – TOP and ACQ. | 151 |
| Figure 14.7: Possible New South Wales and ACT Supply Sources. | 152 |
| Figure 14.8: Probable Supply Scenario – NSW and ACT. | 154 |
| Figure 14.9: Remaining Unfulfilled Market – NSW and ACT. | 155 |
| Figure 14.10: Unfulfilled Reference Gas Demand – SA – TOP and ACQ. | 156 |
| Figure 14.11: Possible South Australian Supply Sources. | 157 |
| Figure 14.12: Probable Supply Scenario – South Australia. | 158 |
| Figure 14.13: Remaining Unfulfilled Market – SA. | 159 |

| | |
|--|-----|
| Figure 14.14: Unfulfilled Reference Gas Demand – QLD – TOP and ACQ..... | 160 |
| Figure 14.15: Remaining Unfulfilled Market – QLD..... | 161 |
| Figure 14.16: Uncontracted Reference Demand in Eastern Australia..... | 161 |
| Figure 14.17: Estimated Ex-field Supply Cost to the Eastern Australian Market..... | 162 |
| Figure 14.18: Probable Supply Sources to Eastern Australia..... | 163 |
| Figure 14.19: Unfulfilled Demand in Eastern Australia after Known Contracts and Probable Supply..... | 164 |
| Figure 14.20: Unfulfilled Demand in Eastern Australia by State..... | 164 |
| Figure 14.21: Variability in the Available Eastern Australian Market..... | 165 |
| Figure 14.22: Unfulfilled Reference Gas Demand – WA – Firm Supply..... | 166 |
| Figure 14.23: Possible Western Australian Supply Sources..... | 167 |
| Figure 14.24: Probable Supply Scenario – Western Australia..... | 168 |
| Figure 14.25: Remaining Unfulfilled Market – Western Australia..... | 169 |