# CONTENTS

*Preface* i

*Acknowledgements* v

Introduction 1
*Lars Ingolf Eide, Linda Curran*

Chapter 1: CCP2 Advisory Board Report: Appraising the Performance and Accomplishments of the $CO_2$ Capture Project - Phase 2 9
*Vello A. Kuuskraa*

**SECTION 1: $CO_2$ CAPTURE**

Chapter 2: Introduction to the CCP2 Capture Technology Portfolio 17
*Ivano Miracca*

Chapter 3: Oxy-Combustion for $CO_2$ Capture from Fluid Catalytic Crackers (FCC) 31
*Leonardo F. de Mello, Gustavo T. Moure, Oscar R. C. Pravia, Loren Gearhart, Paul B. Milios*

Chapter 4: Application of Exhaust Gas Recirculation for Post Combustion $CO_2$ Capture: Effect on Lean Premixed Combustion 43
*Ahmed M. ElKady, Andrei T. Evulet, Anthony R. Brand*

Chapter 5: Chemical Looping Combustion (CLC) Technology Summary 63
*Jan Assink, Corinne Béal*

Chapter 6: Chemical Looping Combustion with Natural Gas using Spray-Dried NiO-based Oxygen Carriers 67
*Carl Linderholm, Anders Lyngfelt, Corinne Béal, Andres Trikkel, Rein Kuusik, Erik Jerndal, Tobias Mattisson*

Chapter 7: Demonstration of Chemical Looping Combustion at Relevant Operating Conditions 75
*T. Pröll, P. Kolbitsch, J. Bolhàr-Nordenkampf, H. Hofbauer*

Chapter 8: NiO-based Oxygen Carriers Impregnated on $Al_2O_3$–based Materials for Chemical Looping Combustion 85
*Juan Adánez, Francisco García-Labiano, Alberto Abad, Luis F. de Diego, Pilar Gayán, Cristina Dueso*

Chapter 9: The Hydrogen Membrane Reformer Pre-combustion Gas Power Cycle 95
*Jens B. Smith, Knut I. Aasen, Kjersti Wilhelmsen, Daniel Käck*

Chapter 10: Introduction to CACHET 115
*Richard Beavis*

Chapter 11: Development of Hydrogen Membrane Reactors for $CO_2$ Capture 121
*J. W. Dijkstra, D. Jansen, R.W. van den Brink, T.A. Peters, M. Stange, R. Bredesen, A. Goldbach, H.Y. Xu, A. Gottschalk, S. Tlatlik, A. Doukelis*

Chapter 12: Development of Thin Pd-23% Ag/Stainless Steel Composite Membranes for Application in Water Gas Shift Membrane Reactors 135
*Thijs Peters, Marit Stange, Rune Bredesen*

Chapter 13: Pilot-scale Development of the Sorption Enhanced Water Gas Shift Process 157
*Ed van Selow, Paul Cobden, Ruud van den Brink, Andrew Wright, Vince White, Peter Hinderink, Jeff Hufton*

Chapter 14: Developing Chemical Looping Steam Reforming and Chemical Looping Autothermal Reforming 181
*Magnus Rydén, Anders Lyngfelt, Alexander Schulman, Luis F. de Diego, Juan Adánez, María Ortiz, Tobias Pröll, Johannes Bolhàr-Nordenkampf, Philipp Kolbitsch*

Chapter 15: One Step Decarbonization 201
*Franco Mizia, Stefano Rossini, Mariangela Cozzolino, Ugo Cornaro, Stephen Tlatlik, Ingeborg Kaus, Egil Bakken, Yngve Larring*

Chapter 16: Hygensys: A New Process for Power Production with Pre-Combustion $CO_2$ Capture 221
*F. Giroudiere, J.L. Ambrosino, B. Fischer, D. Pavone, E. Sanz-Garcia, A. Le Gall, E. Soutif, H.Vleeming*

Chapter 17: Economics 237
*Torgeir Melien, Stefanie Brown-Roijen*

Chapter 18: Overview of the CanmetENERGY $CO_2$ R&D Consortium – Phase 9 265
*Kourosh E. Zanganeh, Milenka Mitrovic, Ahmed Shafeen, Ashkan Beigzadeh, Peter L. Douglas, Eric Croiset, Carlos Salvador, Yewen Tan, Dennis Y. Lu, Robert Dureau, Edward J. Anthony*

Chapter 19: $CO_2$ Capture: Key Findings, Remaining Gaps, Future Prospects 273
*Ivano Miracca*

**SECTION 2: STORAGE, MONITORING AND VERIFICATION**

Chapter 20: CCP2 Storage, Monitoring and Verification: Introduction and Overview 279
*Scott Imbus, Dan Kieke, Linda Curran, Lars Ingolf Eide*

Chapter 21: Model Components of the Certification Framework for Geologic Carbon Storage Risk Assessment 289
*Curtis M. Oldenburg, Steven L. Bryant, Jean-Philippe Nicot, Navanit Kumar, Yingqi Zhang, Preston Jordan, Lehua Pan, Patrick Granvold, Fotini K. Chow*

Chapter 22: Well Integrity Evaluation of a Natural $CO_2$ Producer 317
*Walter Crow, D. Brian Williams, J. William Carey, Michael Celia, Sarah Gasda*

Chapter 23: $CO_2$ Detection – Response Testing of RST in Sandstone Formation Tank Containing $CO_2$ and Water-Based Fluid 331
*Helene Climent*

Chapter 24: A New Reactive Transport Reservoir Simulator for Aquifer Storage of $CO_2$ - with Implicit Geomechanical Analysis 349
*Bjørn Kvamme, Shunping Liu*

Chapter 25: Simulation Study of Methane and Carbon Dioxide Migration and Leakage during Normal and Enhanced Field Operations to Recover Coal Bed Methane from Coal Seams 377
*C. M. F. Galas, V. Y. Savenkov, D. Kieke*

Chapter 26: A Resolution Study of Non-seismic Geophysical Monitoring Tools for Monitoring of $CO_2$ Injection into Coal Beds 403
*Erika Gasperikova, Jinsong Chen*

Chapter 27: Monitoring and Verification of Controlled Releases of $CO_2$ and $CH_4$ using Airborne Remote Sensing 421
*William L. Pickles, Eli A. Silver, James Jacobson*

Chapter 28: CCP2-SMV Program Key Findings, Technology Gaps and the Path Forward 435
*Scott Imbus, Linda Curran*

**SECTION 3: POLICY & INCENTIVES AND COMMUNICATION**

Chapter 29: Assessing Issues of Financing a $CO_2$ Transportation Pipeline Infrastructure 441
*Ioannis Chrysostomidis, Paul Zakkour, Mark Bohm, Eric Beynon, Renato de Filippo, Arthur Lee*

Chapter 30: Communications Summary 453
*Simon Taylor, Iain Wright*

Author Index 459

Subject Index 461