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978-0-521-68551-1 - IPCC Special Report on Carbon Dioxide Capture and Storage

Edited by Bert Metz, Ogunlade Davidson, Heleen de Coninck, Manuela Loos and Leo Meyer

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CARBON DIOXIDE CAPTURE AND STORAGE

This Intergovernmental Panel on Climate Change (IPCC) Special Report provides information for policymakers, scientists and engineers in the field of climate change and reduction of CO₂ emissions. It describes sources, capture, transport, and storage of CO₂. It also discusses the costs, economic potential, and societal issues of the technology, including public perception and regulatory aspects. Storage options evaluated include geological storage, ocean storage, and mineral carbonation. Notably, the report places CO₂ capture and storage in the context of other climate change mitigation options, such as fuel switch, energy efficiency, renewables and nuclear energy.

This report shows that the potential of CO₂ capture and storage is considerable, and the costs for mitigating climate change can be decreased compared to strategies where only other climate change mitigation options are considered. The importance of future capture and storage of CO₂ for mitigating climate change will depend on a number of factors, including financial incentives provided for deployment, and whether the risks of storage can be successfully managed. The volume includes a *Summary for Policymakers* approved by governments represented in the IPCC, and a *Technical Summary*.

The IPCC Special Report on *Carbon Dioxide Capture and Storage* provides invaluable information for researchers in environmental science, geology, engineering and the oil and gas sector, policymakers in governments and environmental organizations, and scientists and engineers in industry.

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Edited by

Bert Metz Ogunlade Davidson Heleen de Coninck
Manuela Loos Leo Meyer

Prepared by Working Group III of the
Intergovernmental Panel on Climate Change

Published for the Intergovernmental Panel on Climate Change



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Cover image: Schematic of geological storage options (Courtesy CO2CRC).

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Foreword

The Intergovernmental Panel on Climate Change (IPCC) was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. Its terms of reference include: (i) to assess available scientific and socio-economic information on climate change and its impacts and on the options for mitigating climate change and adapting to it and (ii) to provide, on request, scientific/technical/socio-economic advice to the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). From 1990, the IPCC has produced a series of Assessment Reports, Special Reports, Technical Papers, methodologies and other products that have become standard works of reference, widely used by policymakers, scientists and other experts.

At COP7, a draft decision was taken to invite the IPCC to write a technical paper on geological storage of carbon dioxide^a. In response to that, at its 20th Session in 2003 in Paris, France, the IPCC agreed on the development of the Special Report on Carbon dioxide Capture and Storage.

This volume, the Special Report on Carbon dioxide Capture and Storage, has been produced by Working Group III of the IPCC and focuses on carbon dioxide capture and storage (CCS) as an option for mitigation of climate change. It consists of 9 chapters covering sources of CO₂, the technical specifics of capturing, transporting and storing it in geological formations, the ocean, or minerals, or utilizing it in industrial processes. It also assesses the costs and potential of CCS, the environmental impacts, risks and safety, its implications for greenhouse gas inventories and accounting, public perception, and legal issues.

Michel Jarraud
Secretary-General,
World Meteorological Organization

As is usual in the IPCC, success in producing this report has depended first and foremost on the knowledge, enthusiasm and cooperation of many hundreds of experts worldwide, in many related but different disciplines. We would like to express our gratitude to all the Coordinating Lead Authors, Lead Authors, Contributing Authors, Review Editors and Expert Reviewers. These individuals have devoted enormous time and effort to produce this report and we are extremely grateful for their commitment to the IPCC process. We would like to thank the staff of the Working Group III Technical Support Unit and the IPCC Secretariat for their dedication in coordinating the production of another successful IPCC report. We are also grateful to the governments, who have supported their scientists' participation in the IPCC process and who have contributed to the IPCC Trust Fund to provide for the essential participation of experts from developing countries and countries with economies in transition. We would like to express our appreciation to the governments of Norway, Australia, Brazil and Spain, who hosted drafting sessions in their countries, and especially the government of Canada, that hosted a workshop on this subject as well as the 8th session of Working Group III for official consideration and acceptance of the report in Montreal, and to the government of The Netherlands, who funds the Working Group III Technical Support Unit.

We would particularly like to thank Dr. Rajendra Pachauri, Chairman of the IPCC, for his direction and guidance of the IPCC, Dr. Renate Christ, the Secretary of the IPCC and her staff for the support provided, and Professor Ogunlade Davidson and Dr. Bert Metz, the Co-Chairmen of Working Group III, for their leadership of Working Group III through the production of this report.

Klaus Töpfer
Executive Director,
United Nations Environment Programme and
Director-General,
United Nations Office in Nairobi

^a See <http://unfccc.int>, Report of COP7, document FCCC/CP/2001/13/Add.1, Decision 9/CP.7 (Art. 3.14 of the Kyoto Protocol), Draft decision -/CMP.1, para 7, page 50: "Invites the Intergovernmental Panel on Climate Change, in cooperation with other relevant organisations, to prepare a technical paper on geological carbon storage technologies, covering current information, and report on it for the consideration of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol at its second session".

Preface

This Special Report on Carbon dioxide Capture and Storage (SRCCS) has been prepared under the auspices of Working Group III (Mitigation of Climate Change) of the Intergovernmental Panel on Climate Change (IPCC). The report has been developed in response to an invitation of the United Nations Framework Convention on Climate Change (UNFCCC) at its seventh Conference of Parties (COP7) in 2001. In April 2002, at its 19th Session in Geneva, the IPCC decided to hold a workshop, which took place in November 2002 in Regina, Canada. The results of this workshop were a first assessment of literature on CO₂ capture and storage, and a proposal for a Special Report. At its 20th Session in 2003 in Paris, France, the IPCC endorsed this proposal and agreed on the outline and timetable^b. Working Group III was charged to assess the scientific, technical, environmental, economic, and social aspects of capture and storage of CO₂. The mandate of the report therefore included the assessment of the technological maturity, the technical and economic potential to contribute to mitigation of climate change, and the costs. It also included legal and regulatory issues, public perception, environmental impacts and safety as well as issues related to inventories and accounting of greenhouse gas emission reductions.

This report primarily assesses literature published after the Third Assessment Report (2001) on CO₂ sources, capture systems, transport and various storage mechanisms. It does not cover biological carbon sequestration by land use, land use change and forestry, or by fertilization of oceans. The report builds upon the contribution of Working Group III to the Third Assessment Report Climate Change 2001 (Mitigation), and on the Special Report on Emission Scenarios of 2000, with respect to CO₂ capture and storage in a portfolio of mitigation options. It identifies those gaps in knowledge that would need to be addressed in order to facilitate large-scale deployment.

The structure of the report follows the components of a CO₂ capture and storage system. An introductory chapter outlines the general framework for the assessment and provides a brief overview of CCS systems. Chapter 2 characterizes the major sources of CO₂ that are technically and economically suitable for capture, in order to assess the feasibility of CCS on a global scale. Technological options for CO₂ capture are discussed extensively in Chapter 3, while Chapter 4 focuses on

methods of CO₂ transport. In the next three chapters, each of the major storage options is then addressed: geological storage (chapter 5), ocean storage (chapter 6), and mineral carbonation and industrial uses (chapter 7). The overall costs and economic potential of CCS are discussed in Chapter 8, followed by an examination of the implications of CCS for greenhouse gas inventories and emissions accounting (chapter 9).

The report has been written by almost 100 Lead and Coordinating Lead Authors and 25 Contributing Authors, all of whom have expended a great deal of time and effort. They came from industrialized countries, developing countries, countries with economies in transition and international organizations. The report has been reviewed by more than 200 people (both individual experts and representatives of governments) from around the world. The review process was overseen by 19 Review Editors, who ensured that all comments received the proper attention.

In accordance with IPCC Procedures, the Summary for Policymakers of this report has been approved line-by-line by governments at the IPCC Working Group III Session in Montreal, Canada, from September 22-24, 2005. During the approval process the Lead Authors confirmed that the agreed text of the Summary for Policymakers is fully consistent with the underlying full report and technical summary, both of which have been accepted by governments, but remain the full responsibility of the authors.

We wish to express our gratitude to the governments that provided financial and in-kind support for the hosting of the various meetings that were essential to complete this report. We are particularly grateful to the Canadian Government for hosting both the Workshop in Regina, November 18-22, 2002, as well as the Working Group III approval session in Montreal, September 22-24, 2005. The writing team of this report met four times to draft the report and discuss the results of the two consecutive formal IPCC review rounds. The meetings were kindly hosted by the government of Norway (Oslo, July 2003), Australia (Canberra, December 2003), Brazil (Salvador, August 2004) and Spain (Oviedo, April 2005), respectively. In addition, many individual meetings, teleconferences and interactions with governments have contributed to the successful completion of this report.

^b See: <http://www.ipcc.ch/meet/session20/finalreport20.pdf>

We endorse the words of gratitude expressed in the Foreword by the Secretary-General of the WMO and the Executive Director of UNEP to the writing team, Review Editors and Expert Reviewers.

We would like to thank the staff of the Technical Support Unit of Working Group III for their work in preparing this report, in particular Heleen de Coninck for her outstanding and efficient coordination of the report, Manuela Loos and Cora Blankendaal for their technical, logistical and secretarial support, and Leo Meyer (head of TSU) for his leadership. We also express our gratitude to Anita Meier for her general support, to Dave Thomas, Pete Thomas, Tony Cunningham, Fran Aitkens, Ann Jenks, and Ruth de Wijs for the copy-editing of the document and to Wout Niezen, Martin Middelburg, Henk Stakelbeek, Albert van Staa, Eva Stam and Tim Huliselan for preparing the final layout and the graphics of the report. A special word of thanks goes to Lee-Anne Shepherd of CO2CRC for skillfully preparing the figures in

the Summary for Policymakers. Last but not least, we would like to express our appreciation to Renate Christ and her staff and to Francis Hayes of WMO for their hard work in support of the process.

We, as co-chairs of Working Group III, together with the other members of the Bureau of Working Group III, the Lead Authors and the Technical Support Unit, hope that this report will assist decision-makers in governments and the private sector as well as other interested readers in the academic community and the general public in becoming better informed about CO₂ capture and storage as a climate change mitigation option.

Ogunlade Davidson and Bert Metz
Co-Chairs IPCC Working Group III on Mitigation of Climate Change