Carbon Dioxide Removal From Coal Fired Power Plants 1st Edition

A concise overview of carbon dioxide capture and storage (CCS), a promising but overlooked climate change mitigation pathway. The burning of fossil fuels releases carbon dioxide (CO2), and these CO2 emissions are a major driver of climate change. Carbon capture offers a path to climate change mitigation that has received relatively little attention. In this volume in the MIT Press Essential Knowledge series, Howard Herzog offers a concise guide to carbon capture, covering basic information as well as the larger context of climate technology and policy. Carbon capture, or carbon dioxide capture and storage (CCS), refers to a suite of technologies that reduce CO2 emissions by "capturing" CO2 before it is released into the atmosphere and then transporting it to where it will be stored or used. It is the only climate change mitigation technique that deals directly with fossil fuels rather than providing alternatives to them. Herzog, a pioneer in carbon capture research, begins by discussing the fundamentals of climate change and how carbon capture can be one of the solutions. He explains capture and storage technologies, including chemical scrubbing and the injection of CO2 deep underground. He reports on current efforts to deploy CCS at factories and power plants and attempts to capture CO2 from the air itself. Finally, he explores the policies and politics in play around CCS and argues for elevating carbon capture in the policy agenda.

"Over the past 20 years, the concept of storing or permanently storing carbon dioxide in geological media has gained increasing attention as part of the important technology option of carbon capture and storage within a portfolio of options aimed at reducing anthropogenic emissions of greenhouse gases to the earth's atmosphere. Research programs focusing on the establishment of field demonstration projects are being implemented worldwide to investigate the safety, feasibility, and permanence of carbon dioxide geological sequestration. AAPG Studies 59 presents a compilation of state of the science contributions from the international research community on the topic of carbon dioxide sequestration in geological media, also called geosequestration. This book is structured into eight parts, and, among other topics, provides an overview of the current status and challenges of the science, regional assessment studies of carbon dioxide geological sequestration potential, and a discussion of the economics and regulatory aspects of carbon dioxide sequestration."--P. [4] of cover.

Elevated levels of carbon dioxide in the atmosphere have created numerous environmental and socio-economic problems, including climate change. The scientific community is experimenting with various emission reduction and carbon capture and storage strategies. Mineral sequestration of carbon with alkaline industrial residues is one such emerging emission reduction technology which is being researched for its ability to be integrated into industrial plants, where both carbon dioxide (CO2)and alkaline solid residues are generated on site. This concept can be applied to the coal-fired power generation industry, which produces enormous quantities of coal fly ash as a solid by-product along with massive emissions of gaseous CO2 with the flue gas stream. Therefore, the mineral trapping of CO2 with coal fly ash can help to sustain coal-based power generation, while bringing added advantages to fly ash disposal due to the favourable chemical changes which occur in fly ash during the above carbonation process. However, mineral carbonation to date remains an immature technology due to its main drawbacks related to kinetics and extensive research is necessary to find acceleration to accelerate mineral sequestration. The main aim of the present thesis is to investigate the effect of operational parameters on the accelerated carbonation of coal combustion fly ash and to study the effect of carbonation on the final disposal of fly ash, especially in relation to agricultural soil amendment.The research work is based on experimental studies conducted in the laboratory and in a greenhouse facility. The accelerated carbonation tests for fly ash were conducted in a newly-developed reactor facility in the Deep Earth Energy Research Laboratory in the Civil Engineering Department at the Clayton campus of Monash University. The main component of this facility is a continuously stirred cylindrical tank equipped with adjustable temperature and pressure mechanisms and monitoring and data acquisition systems. The fly ash materials were collected from the collection ponds of three major power plants located in the Latrobe Valley in Victoria, Australia. The carbonation reactions were designed to test the effect of reaction temperature (in the range of 20 0C to 80 0C), initial CO2 pressure inside the reactor (in the range of 1MPa to 10 MPa), water-to-solid ratio or solid dosage (in the range of 0.1 to 1) and the super-critical phase of CO2. In addition, the effect of fly ash particle size was tested with five different particle size categories varying from

Negative Emissions Technologies and Reliable Sequestration

QUANTIFYING POTENTIAL OF THE BLACK WARRIOR COALBED METHANE FAIRWAY, ALABAMA.

CO2 Reduction

Prospects and Policy Issues

Geologic Carbon Sequestration

Removing the Legal and Regulatory Barriers

To achieve goals for climate and economic growth, "negative emissions technologies" (NETs) that remove and sequester carbon dioxide from the air will need to play a significant role in mitigating climate change. Unlike carbon capture and storage technologies that remove carbon dioxide emissions directly from large point sources such as coal power plants, NETs remove carbon dioxide directly from the atmosphere or enhance natural carbon sinks. Storing the carbon dioxide from NETs has the same impact on the atmosphere and climate as simultaneously preventing an equal amount of carbon dioxide from being emitted. Recent analyses found that deploying NETs may be less expensive and less disruptive than reducing some emissions, such as a substantial portion of agricultural and land-use emissions and some transportation emissions. In 2015, the National Academies published Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration, which described and initially assessed NETs and sequestration technologies. This report acknowledged the relative paucity of research on NETs and recommended development of a research agenda that covers all aspects of NETs from fundamental science to full-scale deployment. To address this need, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda assesses the benefits, risks, and "sustainable scale potential" for NETs and sequestration. This report also defines the essential components of a research and development program, including its estimated costs and potential impact.

Our inability to curb CO2 emissions has increased interest in geoengineering: "the deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change." One of the safest types of geoengineering is carbon dioxide removal from the air, which is generally very expensive and resource intensive. On the other hand, the electricity generation sector has a number of options to lower carbon emissions, and the emissions from electricity also influence the efficacy of atmospheric CO2 removal technologies. Because removing carbon from the atmosphere and preventing emissions from electricity generation are equivalent from a climate perspective, it is desirable to compare them on a quantitative basis. However, because technologies to remove carbon dioxide from the air and low-carbon electricity are designed for different purposes and services, it is very difficult to find the appropriate quantitative metrics for comparison. In order to compare disparate systems fairly we use a broader definition of carbon avoided, one which includes life-cycle emissions and uses a common reference electricity mix for all technologies considered. Using this metric we compare two currently-deployable carbon-negative options (one biological and one chemical) against several electricity generation technologies both with and without carbon capture and sequestration. The electricity generation technologies with carbon capture include current state-of-the-art coal and natural gas electricity, and the low-carbon electricity generation technologies without carbon capture include nuclear and wind electricity. We evaluate the systems on the basis of: carbon avoided per unit of physically captured carbon; energy consumption per unit of carbon avoided; and cost per unit of carbon avoided. We use the present day average U.S. electricity mix as the initial reference electricity, and then vary the carbon intensity and cost in order to understand the sensitivity of the results. We show that on an energy and cost per unit avoided basis, the biological atmospheric CO2 removal system is strongly favored over the chemical system of atmospheric CO2 evaluated. We also show that when considered relative to a common reference, the biological atmospheric CO2 removal system (a bioelectricity system with carbon capture and sequestration) is less expensive and more efficient for avoiding carbon than either a natural gas or coal electricity generation system with carbon capture and sequestration. However, overall we show that the least expensive option for avoiding carbon in the electricity system of the U.S. today is by generating wind electricity. The next lowest cost options for avoiding carbon are by generating nuclear electricity or bioelectricity with carbon capture and sequestration. The system for bioelectricity with carbon capture and sequestration investigated here only becomes less expensive than wind electricity for avoiding emissions once the electricity emissions of the overall U.S. electricity mix are reduced by about 80%.

Carbon Dioxide Removal and Reliable Sequestration

Sequestration and Storage

Carbon Dioxide Removal from Coal-Fired Power Plants

Absorption-Based Post-Combustion Capture of Carbon Dioxide

Carbon Capture and Sequestration

A Research Agenda

In this project TDA Research, Inc (TDA) has developed a new post combustion carbon capture technology based on a vacuum swing adsorption system that uses a steam purge and demonstrated its technical feasibility and economic viability in laboratory-scale tests and tests in actual coal derived flue gas. TDA uses an advanced physical adsorbent to selectively remove CO_2 from the flue gas. The sorbent exhibits a much higher affinity for CO_2 than N_2, H_2O or O_2, enabling effective CO_2 separation from the flue gas. We also carried out a detailed process design and analysis of the new system as part of both sub-critical and super-critical pulverized coal fired power plants. The new technology uses a low cost, high capacity adsorbent that selectively removes CO_2 in the presence of moisture at the flue gas temperature without a need for significant cooling of the flue gas or moisture removal. The sorbent is based on a TDA proprietary mesoporous carbon that consists of surface functionalized groups that remove CO_2 via physical adsorption. The high surface area and favorable porosity of the sorbent also provides a unique platform to introduce additional functionality, such as active groups to remove trace metals (e.g., Hg, As). In collaboration with the Advanced Power and Energy Program of the University of California, Irvine (UCI), TDA developed system simulation models using Aspen PlusTM simulation software to assess the economic viability of TDA's VSA-based post-combustion carbon capture technology. The levelized cost of electricity including the TS & M costs for CO_2 is calculated as $116.71/MWh and $113.76/MWh for TDA system integrated with sub-critical and super-critical pulverized coal fired power plants; much lower than the $153.03/MWhand $147.44/MWh calculated for the corresponding amine based systems. The cost of CO_2 captured for TDA's VSA based system is $38.90 and $39.71 per tonne compared to $65.46 and $66.56 per tonne for amine based system on 2011 $ basis, providing 40% lower cost of CO_2 captured. In this analysis we have used a sorbent life of 4 years. If a longer sorbent life can be maintained (which is not unreasonable for fixed bed commercial PSA systems), this would lower the cost of CO_2 captured by $0.05 per tonne (e.g., to $38.85 and $39.66 per tonne at 5 years sorbent replacement). These system analysis results suggest that TDA's VSA-based post-combustion capture technology can substantially improve the power plant's thermal performance while achieving near zero emissions,

including greater than 90% carbon capture. The higher net plant efficiency and lower capital and operating costs results in a substantial reduction in the cost of carbon capture and cost of electricity for the power plant equipped with TDA's technology.
Reports on methods of capturing and storing CO2 from major sources to reduce the levels emitted to the atmosphere by human activities.
Best practices for mitigating environmental damage fromconventional power generation This volume of the Wiley Series in Environmentally ConsciousEngineering, Environmentally Conscious Fossil EnergyProduction, seeks to provide new solutions to one of the grandchallenges of this century: supplying energy to a growingpopulation while reducing environmental pollution and greenhousegas emissions. The first five chapters cover extraction andtransport of fossil fuels; the last four chapters cover powerplants. An international roster of contributors, from the UnitedStates, Canada, and the Middle East, deals with the wide variety ofchallenges posed by converting oil, natural gas, and coal toenergy. Chapters include: Environmentally Conscious Petroleum Engineering Carbon Management and Hydrogen Requirements in Oil Sands Environmentally Conscious Coal Mining Maritime Oil Transport and Pollution Prevention Accidental Oil Spills Behavior and Control Geological Sequestration of Greenhouse Gases Clean Coal Technology: Gasification Pathway An Integrated Approach for Carbon Mitigation in the ElectricPower Generation Sector Energy and Exergy Analyses of Natural Gas Fired Combined CyclePower Generation Systems Turn to all of the books in the Wiley Series inEnvironmentally Conscious Engineering for the mostcutting-edge, environmentally friendly engineering practices andtechnologies.
Advances in Carbon Capture and Utilization
Prospects for Coal
Low Cost, High Capacity Regenerable Sorbent for Carbon Dioxide Capture from Existing Coal-fired Power Plants
Awareness and Capacity Building
Carbon Capture
State of the Science, AAPG Studies in Geology 59

Large U.S. coal reserves and viable technology make promising a domestic industry producing liquid fuels from coal. Weighing benefits, costs, and environmental issues, a productive and robust U.S. strategy is to promote a limited amount of early commercial experience in coal-to-liquids production and to prepare the foundation for managing associated greenhouse-gas emissions, both in a way that reduces uncertainties and builds future capabilities.

This exclusive compilation written by eminent experts from more than ten countries, outlines the processes and methods for geologic sequestration in different sinks. It discusses and highlights the details of individual storage types, including recent advances in the science and technology of carbon storage. The topic is of immense interest to geoscientists, reservoir engineers, environmentalists and researchers from the scientific and industrial communities working on the methodologies for carbon dioxide storage. Increasing concentrations of anthropogenic carbon dioxide in the atmosphere are often held responsible for the rising temperature of the globe. Geologic sequestration prevents atmospheric release of the waste greenhouse gases by storing them underground for geologically significant periods of time. The book addresses the need for an understanding of carbon reservoir characteristics and behavior. Other book volumes on carbon capture, utilization and storage (CCUS) attempt to cover the entire process of CCUS, but the topic of geologic sequestration is not discussed in detail. This book focuses on the recent trends and up-to-date information on different storage rock types, ranging from deep saline aquifers to coal to basaltic formations.

A material for the removal of carbon dioxide from a gas stream is reported. The overall process consists of synthesizing the material, characterization, and reactivity/capacity testing of the removal agent. In the synthesis process a dolomitic material $CaCO_3$:$MgCO_3$ are co-precipitated by carbon dioxide from a solution made with specific amounts of commercially available CaO and MgO. Characterization was done with BET to determine specific surface area, pore size distribution, specific pore volume; particle size analysis to determine particle size distribution, mean particle size, and d_{50} ; SEM/EDS was used to determine surface morphology and Ca:Mg ratio. The reactivity and capacity was measured using TGA by running multiple 20 minute reaction-regeneration cycles at 750°C, one cycle at 800 and 850°C, and a long term test was run on the optimal sample. Reaction cycles were carried out under 100% carbon dioxide and the regeneration cycles were run under nitrogen. The effects of CaO, MgO, and surfactant loading were studied to determine the maximum amount of carbon dioxide removal for the

sorbents.
Understanding Reservoir Behavior
Carbon Capture, Storage and Utilization
Ending Fossil Fuels
A Possible Climate Change Solution for Energy Industry
Physical, Chemical, and Biological Methods
Calculating the Energy Cost of CO2 Removal in a Coal Based Gas Turbine Fuel Cell Hybrid Power Generation System with an Isolated Anode Stream

Sequestration of CO2 in coal has potential to reduce greenhouse gas emissions from coal-fired power plants while enhancing coalbed methane recovery. Data from more than 4,000 coalbed methane wells in the Black Warrior basin of Alabama provide an opportunity to quantify the carbon sequestration potential of coal and to develop a geologic screening model for the application of carbon sequestration technology. This report summarizes stratigraphy and sedimentation, structural geology, geothermics, hydrology, coal quality, gas capacity, and production characteristics of coal in the Black Warrior coalbed methane fairway and the implications of geology for carbon sequestration and enhanced coalbed methane recovery. Coal in the Black Warrior basin is distributed among several fluvial-deltaic coal zones in the Lower Pennsylvanian Pottsville Formation. Most coal zones contain one to three coal beds that are significant targets for coalbed methane production and carbon sequestration, and net coal thickness generally increases southeastward. Pottsville strata have effectively no matrix permeability to water, so virtually all flow is through natural fractures. Faults and folds influence the abundance and openness of fractures and, hence, the performance of coalbed methane wells. Water chemistry in the Pottsville Formation ranges from fresh to saline, and zones with TDS content lower than 10,000 mg/L can be classified as USDW. An aquifer exemption facilitating enhanced recovery in USDW can be obtained where TDS content is higher than 3,000 mg/L. Carbon dioxide becomes a supercritical fluid above a temperature of 88 F and a pressure of 1,074 psi. Reservoir temperature exceeds 88 F in much of the study area. Hydrostatic pressure gradients range from normal to extremely underpressured. A large area of underpressure is developed around closely spaced longwall coal mines, and areas of natural underpressure are distributed among the coalbed methane fields. The mobility and reactivity of supercritical CO2 in coal-bearing strata is unknown, and potential exists for supercritical conditions to develop below a depth of 2,480 feet following abandonment of the coalbed methane fields. High-pressure adsorption isotherms confirm that coal sorbs approximately twice as much CO2 as CH4 and approximately four times as much CO2 as N2. Analysis of isotherm data reveals that the sorption performance of each gas can vary by a factor of two depending on rank and ash content. Gas content data exhibit extreme vertical and lateral variability that is the product of a complex burial history involving an early phase of thermogenic gas generation and an ongoing stage of late biogenic

gas generation. Production characteristics of coalbed methane wells are helpful for identifying areas that are candidates for carbon sequestration and enhanced coalbed methane recovery. Many geologic and engineering factors, including well construction, well spacing, and regional structure influence well performance. Close fault spacing limits areas where five-spot patterns may be developed for enhanced gas recovery, but large structural panels lacking normal faults are in several gas fields and can be given priority as areas to demonstrate and commercialize carbon sequestration technology in coalbed methane reservoirs.

Carbon capture and storage (CCS) is among the advanced energy technologies suggested to make the conventional fossil fuel sources environmentally sustainable. It is of particular importance to coal-based economies. This book deals at length with the various aspects of carbon dioxide capture, its utilization and takes a closer look at the earth processes in carbon dioxide storage. It discusses potential of Carbon Capture, Storage, and Utilization as innovative energy technology towards a sustainable energy future. Various techniques of carbon dioxide recovery from power plants by physical, chemical, and biological means as well as challenges and prospects in biomimetic carbon sequestration are described. Carbon fixation potential in coal mines and in saline aquifers is also discussed. Please note: This volume is Co-published with The Energy and Resources Institute Press, New Delhi. Taylor & Francis does not sell or distribute the Hardback in India, Pakistan, Nepal, Bhutan, Bangladesh and Sri Lanka

Absorption-Based Post-Combustion Capture of Carbon Dioxide provides a comprehensive and authoritative review of the use of absorbents for post-combustion capture of carbon dioxide. As fossil fuel-based power generation technologies are likely to remain key in the future, at least in the short- and medium-term, carbon capture and storage will be a critical greenhouse gas reduction technique. Post-combustion capture involves the removal of carbon dioxide from flue gases after fuel combustion, meaning that carbon dioxide can then be compressed and cooled to form a safely transportable liquid that can be stored underground. Provides researchers in academia and industry with an authoritative overview of the amine-based methods for carbon dioxide capture from flue gases and related processes Editors and contributors are well known experts in the field Presents the first book on this specific topic

CO2 Sequestration Technologies for Clean Energy

Carbon Utilization

Novel Dual-Functional Membrane for Controlling Carbon Dioxide Emissions from Fossil Fuel Power Plants

A Review of Current Capture Techniques and an Investigation of Carbon Dioxide Absorption Using Hybrid Solvents

Environmental Control Technology for Atmospheric Carbon Dioxide

Thermodynamic Considerations for Carbon Dioxide Removal from Flue Gases Issued from Coal Combustion

This book is the first systematic presentation of the technical, legal, and economic forces that must coalesce to realize carbon dioxide capture and geologic sequestration as a viable CO2 reduction *strategy. It synthesizes key engineering data and explains the technological and legal conditions that must be in place for carbon sequestration to be realized.*

This book provides in-depth information on topics relating to anthropogenic carbon dioxide utilization processes. Presenting a collection of state-of-the-art scientific reviews and research perspectives on carbon management strategies of relevance to the energy industry, it features contributions by leading scientists and technocrats across 19 chapters as an Indian contribution In the energy industry, new processes for carbon dioxide removal and recycling are developing quickly, and it is in this context that the book provides an opportunity to review the current status of and promote efforts to achieve effective carbon capture and management. The contents presented here will prove useful to researchers, students, industry experts, scientists and policymakers alike.

The book CO2 Sequestration Technologies for Clean Energy is about management of CO2 by capturing and fixing it away from the atmosphere for clean energy development. Energy industry is the target industry for adoption of CCS in fossil fuel based economies. In a coal based power plant CO2 can be captured at various stages of pre-combustion, during combustion and post combustion. Research work being carried out on mixed metal oxides as CO2 absorbents for pre-combustion capture and pressure swing adsorption techniques for CO2 post combustion capture are discussed in two different chapters. These and new coal combustion technology such as oxy coal combustion, issues in long-term climate change challenge, corporate response as well as perspectives in CO2 sequestration pathways including policy assessments are covered in separate Chapters from 1 to 6. Biological methods of post combustion CO2 sequestration are dealing with microalgae and microbial research. Ongoing research on photo bioreactors and solar bio-reactors; safe and novel concepts using different micro-remediation techniques for permanent capture of CO2 are explained in Chapters 7, 9, 10. Can underground CO2 sequestration result in value added products from depleted or abandoned oil or coal fields? We cover CO2 sequestration perspectives and assessment in Oil sector and prospects of enhanced coal bed methane recovery in Coal sector with recent efforts made in Chapters 8, 11, 12. Approach to storage of CO2 in ocean waters and fertilization of phytoplankton is described in Chapter 13. Chapter 14 deals with soil and vegetation sequestration of CO2 in forest ecosystem. Chapter 15 exclusively presents views of the experts on CO2 mitigation strategies in Power sector. Open roundtable discussion on clean development mechanism, views expressed on financing approaches as well as technical issues in the context of greenhouse gas emissions and clean energy fuels are presented in Chapter 16. Research results in physical, biological and chemical methods of CO2 sequestration are described in a lucid manner with explanations and examples to create awareness among different sectors of economy. This book is useful for the scientists, technologists and policy makers working on clean energy and environment. Contents Chapter 1: Corporate Response to Climate Change by S.Z. Qasim; Chapter 2: Carbon Capture and Storage Technology: A Possible Long Term Solution to Climate

Change Challenge by R.V. Shahi; Chapter 3: Perspectives in CO2 Sequestration Technology and an Awareness Programme by Malti Goel; Chapter 4: Post Combustion Capture of CO2 by Anshu Nanoti and Amar N. Goswami; Chapter 5: Carbon Dioxide Sequestration Over Mixed Metal Oxide Adsorbents at Higher Temperatures by A.G. Gaikwad; Chapter 6: Oxy Fuel Combustion by M. Soundaraj Raj; Chapter 7: CO2 Sequestration and Biofuel Production Using Micro Algal Technology by M. Premalatha, K.K. Vasumathi, K. Sudhakar; Chapter 8: Carbon Capture and Sequestration by D.M. Kale; Chapter 9: Role of Algae in Carbon Sequestration by Dinabandhu Sahoo; Chapter 10: Enzyme and Microbe Mediated Carbon Sequestration by Adarsh K. Puri and T. Satyanarayana; Chapter 11: Opportunities for Extraction and Utilization of Coal Mine Methane and Enhanced Coal Bed Methane Recovery in India by Ajay Kumar Singh; Chapter 12: Coal Bed Methane: Prospects and Challenges by V.A. Mendhe; Chapter 13: Oceans: A Ready Solution or a Last Frontier in Carbon Dioxide Mitigation? by Nittala S. Sarma; Chapter 14: Soil and Vegetation Carbon Pool and Sequestration in the Forest Ecosystems of Manipur, NE India by P.S. Yadava; Chapter 15: CO2 Mitigation: Issues and Strategies by V.S. Verma; Chapter 16: Should Carbon Be Priced?: Open Round Table Discussion.

Environmentally Conscious Fossil Energy Production

Carbon Sequestration

Producing Liquid Fuels from Coal

Engineering and Economic Evaluation of COb2s Removal from Fossil-fuel-fired Power Plants: Coal gasification-combined-cycle power plants

Environmental Control Technology for Atmospheric Carbon Dioxide, Final Report

Why Net Zero is Not Enough

Around the world, countries and companies are setting net-zero carbon emissions targets. But net-zero is a term that conveniently obscures multiple futures. There could be a version of net-zero where the fossil fuel industry is still spewing tens of billions of tons of CO2 into the atmosphere, and has built a corresponding industry in sucking it back out again. Holly Buck argues that focusing on emissions draws our attention away from where we need to be looking: the point of production. It is time to plan for the end of fossil fuel and the companies that profit from them. Fossil fuels still provide 80% of world energy and ceasing their use before there are ready alternatives brings risks of energy poverty. The fossil fuel industry provides jobs, as well as a source of revenue for some frontline communities. Conventional wisdom says that fossil fuels will be naturally priced out when cheaper, but this raises as many problems as it addresses. Ending Fossil Fuels tackles these problems seriously and also sets out a roadmap that offer opportunities for more liveable, inclusive future.

Carbon Capture and Storage is a key technology for a sustainable and low carbon economy. This book unites top academic and industry researchers in search for commercial concepts for CCS at coal power ploants. This reference focuses on power plant technology and ways to improve efficiency. It details the three principal ways of capturing the CO2 produced in power plants:

oxyfuel combustion, postcombustion and precombustion, with the main part concentrating on the different approaches to removing carbon dioxide. Wtih an eye on safety, the authors explain how the three parts of the CCS chain work - capture, transport and storage - and how they can be performed safely. The result is specific insights for process engineers, chemists, physicists and materials engineers in their relevant fields, as well as a sufficiently broad scope to be able to understand the opportunities and implications of the other disciples.

Carbon Dioxide Removal from Coal-Fired Power PlantsSpringer Science & Business Media

Climate Intervention

Research and Development Report - Office of Coal Research

Prospects for Advanced Coal Technologies

Surface Modified Dolomitic Sorbent for Carbon Dioxide Removal for Hydrogen Production from Coal

Carbon Dioxide Capture and Storage

Special Report of the Intergovernmental Panel on Climate Change

CO2 captured from coal-fired power plants represents three-quarters of the total cost of an entire carbon sequestration process. Conventional amine absorption or cryogenic separation requires high capital investment and is very energy intensive. Our novel membrane process is energy efficient with great potential for economical CO2 capture. Three classes of microporous sol-gel derived silica-based membranes were developed for selective CO2 removal under simulated flue gas conditions (SFG), e.g. feed of 10% vol. CO22 in N2, 1 atm total pressure, T = 50-60 C, RH>50%, SO2>10 ppm. A novel class of amine-functional microporous silica membranes was prepared using an amine-derivatized alkoxysilane precursor, exhibiting enhanced (>70) CO2:N2 selectivity in the presence of H2O vapor, but its CO2 permeance was lagging (

This book focuses on the recent trends in carbon management and up-to-date information on different carbon management strategies that lead to manage increasing concentration of atmospheric carbon dioxide. The growing evidence of climate change resulting from the continued increase of atmospheric carbon dioxide concentration has made it a high profile political–social and trade issue. The mean global average earth temperature rose by 0.6± 20C during the second half of the century with the rate of 0.170C/decade. As per GISS data in the year of 2017, it rose 0.90C (1.62 0F) above the 1951-1980 mean global temperature. Recently World Meteorological Organization analyzes the past record temperature and found the past 10 years were the warmest years about 1.10C above preindustrial level. Over the past decade, carbon management by various techniques has to come to fore as a way to manage carbon dioxide emissions contributing to climate change. The proposed book addresses the need for an understanding of sustainable carbon dioxide management technologies mainly focused on (a) minimizing carbon dioxide emission from sources; (b) maximizing environmentally sound recuse, reduce and recycling; (c)emerging technology toward carbon dioxide mitigation and d) converting carbon dioxide into valuable products form sustainable use. Other books related to carbon management attempt to cover the carbon capture and sequestration, carbon mineralization, utilization and storage but the topic of CO2 management strategies is not discussed in detail for sustainable development. Furthermore, this book also covers all physical, chemical and biological process for long-term capture, removal and sequestration of carbon dioxide from the atmosphere for sustainable management which is not described in other carbon management books. In order to meet CO2 emissions reduction target, a range of technological approaches, including development of clean fuels and clean coal technologies, adopting cleaner and more energy efficiency and conservation, developing renewable energy and implementing CCS technologies, will also be considered for sustainable future.

A novel carbon dioxide (CO2) capture method by using environment-friendly chemical magnesium hydroxide (Mg(OH)2) solution has been proposed and is currently under investigation in response to controlling the CO2 emissions from coal-fired power plant in the post-combustion control area. The major goal of this research is to (1). Select and design an appropriate absorber which can offer 90% plus CO2 removal efficiency with low energy costs; (2). Find and optimize the operation conditions for the regeneration step. The results of experimental investigation and discussion of desorption energy requirement are presented. Turbulent contacting absorber (TCA) and bubble column absorber have been tested as primary CO2 mass transfer devices. Both batch and continuous mode of operations were performed. Important parameters including liquid-to-gas ratio, residence time, lean solvent concentration, pressure drop, bed height, CO2 partial pressure, bubble size, pH, and temperature have been carefully evaluated. The n-CSTR model has been developed to analyze the TCA absorption data. It is found that TCA reactor used in this research can be adequately modeled when n=7. Also, the mass transfer controlling step of TCA was examined. It is found that TCA operation might be divided into two regimes based on the OH- concentration. The bubble column absorber results reveal that the scrubbing performance heavily depends on the gas residence time and size of bubble. It is found that 90% plus CO2 removal efficiency can be achieved at L/G ratio of 120 gal liquid/1000 acf gas and 8 seconds of gas residence. A bubble column reactor model was developed for CO2 removal data analysis. The model incorporated physical absorption between CO2 and water, dissolution of Mg(OH)2 solid particles, diffusion within the gas and liquid phases, and chemical reactions of the ions. The overall mass transfer coefficient, a key designing parameter, is found to be a function of the hydrodynamic parameters, Henry's constant, CO2 partial pressure in the gas phase, diffusivities, solid dissolution constant and temperature. The overall mass transfer coefficients found from this study are comparable to the other widely studied scrubbing chemicals, such as MEA and ammonia solutions. Also, the experimental investigations of regeneration are given. Regeneration conditions have been identified and a possible regeneration mechanism was found. Mg(HCO3)2 is completely soluble and can be reversed by temperature, but MgCO3, when formed, is a solid and very energy intensive to regenerate. A temperature swing regeneration process has been shown to be effective in recovering CO2 and regenerating Mg(OH)2. Finally, the vapor-liquid equilibrium data of CO2-Mg(OH)2 system and energy analysis of desorption step have been presented. It is found that the total desorption energy consumption mainly consists of heat of desorption, water vaporization energy, and the energy required for temperature raise in the stripper. The results suggest that 167 MW is required for bicarbonate only desorption case; while 232 MW is required for carbonate solid only desorption case at a scale of 500 MW coal-fired power plant.

Study of the Accelerated Carbonation of Coal Fly Ash for Carbon Dioxide Sequestration and Soil Amendment

The Removal of Methane from Coal Gasification Products Using Liquid Carbon Dioxide, a

Computer Model for a High Pressure Gas Cleanup Process

Efficient Carbon Capture for Coal Power Plants

A Systems Study for the Removal, Recovery and Disposal of Carbon Dioxide from Fossil Fuel Power Plants in the U.S.

Advances in Carbon Management Technologies

Carbon Removal, Renewable and Nuclear Energy, Volume 1

The signals are everywhere that our planet is experiencing significant climate change. It is clear that we need to reduce the emissions of carbon dioxide and other greenhouse gases from our atmosphere if we want to avoid greatly increased risk of damage from climate change. Aggressively pursuing a program of emissions abatement or mitigation will show results over a timescale of many decades. How do we actively remove carbon dioxide from the atmosphere to make a bigger difference more quickly? As one of a two-book report, this volume of Climate Intervention discusses CDR, the carbon dioxide removal of greenhouse gas emissions from the atmosphere and sequestration of it in perpetuity. Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration introduces possible CDR approaches and then discusses them in depth. Land management practices, such as low-till agriculture, reforestation and afforestation, ocean iron fertilization, and land-and-ocean-based accelerated weathering, could amplify the rates of processes that are already occurring as part of the natural carbon cycle. Other CDR approaches, such as bioenergy with carbon capture and sequestration, direct air capture and sequestration, and traditional carbon capture and sequestration, seek to capture CO2 from the atmosphere and dispose of it by pumping it underground at high pressure. This book looks at the pros and cons of these options and estimates possible rates of removal and total amounts that might be removed via these methods. With whatever portfolio of technologies the transition is achieved, eliminating the carbon dioxide emissions from the global energy and transportation systems will pose an enormous technical, economic, and social challenge that will likely take decades of concerted effort to achieve. Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration will help to better understand the potential cost and performance of CDR strategies to inform debate and decision making as we work to stabilize and reduce atmospheric concentrations of carbon dioxide.

Please note that the content of this book primarily consists of articles available from Wikipedia or other free sources online. Pages: 31. Chapters: Blue carbon, Carbon capture and storage, Carbon capture and storage (timeline), Carbon dioxide removal, Carbon sequestration in terrestrial ecosystems, Carbon sink, NOTT-202. Excerpt: Carbon capture and storage (CCS) (or carbon capture and sequestration), is the process of capturing waste carbon dioxide (CO2) from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation. The aim is to prevent the release of large quantities of CO2 into the atmosphere (from fossil fuel use in power generation and other industries). It is a potential means of mitigating the contribution of fossil fuel emissions to global warming and ocean acidification. Although CO2 has been injected into geological formations for several decades for various purposes, including enhanced oil recovery, the long term storage of CO2 is a relatively new concept. The first commercial example was Weyburn in 2000. 'CCS' can also be used to describe the scrubbing of CO2 from ambient air as a geoengineering technique. An integrated pilot-scale CCS power plant was to begin operating in September 2008 in the eastern German power plant Schwarze Pumpe run by utility Vattenfall, in the hope of answering questions about technological feasibility and economic efficiency. CCS applied to a modern conventional power plant could reduce CO2 emissions to the atmosphere by approximately 80-90% compared to a plant without CCS. The IPCC estimates that the economic

potential of CCS could be between 10% and 55% of the total carbon mitigation effort until year 2100. Capturing and compressing CO2 may increase the fuel needs of a coal-fired CCS plant by 25-40%. These and other system costs are estimated to increase the cost of the energy...

In recent years there has been significant interest in identifying carbon capturing technologies that can be applied to fossil fuel power generation plants. CO2 capture technologies seek to reduce the amount of CO2 that would normally be emitted into the atmosphere from the daily operation of these plants. In terms of system efficiency and operating costs, this carbon capture is expensive. Further, the additional equipment that would be used to capture CO2 emissions greatly adds to the complexity of the system. There has also been significant interest in coal based gas turbine fuel cell hybrid power plants. A hybrid power plant can have much greater system efficiency than a normal gas turbine power plant because the heat that is normally unused in a standalone solid oxide fuel cell (SOFC) is recovered and used to drive a power producing turbine. It is thought that the increased system efficiency of the hybrid system might compensate for the increased expense of performing carbon capture. In order to provide some analytical insight on this tradeoff we present a 100 MW class coal fired gas turbine SOFC hybrid power generation system. The hybrid system operates at a pressure ratio of 6, and uses heat recuperation and cathode air recirculation to control the SOFC inlet temperature and the temperature change across the SOFC. A carbon capture scheme is added to this system in order to calculate the relative energy cost in terms of system efficiency due to CO2 ompression. The carbon capture is performed by burning the unused fuel from the SOFC in an isolated anode stream using pure O2 injection. The resulting heat that is generated from this process is then used to drive a secondary turbine that is placed in the anode exhaust stream where more work is extracted. With an isolated anode stream, the products of combustion from this secondary combustion process are mostly water and carbon dioxide. The water by-product is then condensed out of the stream leaving a relatively high concentration of CO2. This is then compressed, and removed from the system. In this study we present power plant efficiency calculations for the performance of the hybrid system with the carbon capturing loop. Our results show the effects on system performance that result from a changing fuel utilization factor.

Blue Carbon, Carbon Capture and Storage, Carbon Capture and Storage (Timeline), Carbon Dioxide Removal, Carbon Sequestration In Applications for the Energy Industry

GEOLOGIC SCREENING CRITERIA FOR SEQUESTRATION OF CO2 IN COAL

Energy and Cost Comparison Per Carbon Avoided for CO2 Removal from Air Compared to Low-carbon Electricity

Efficient Energy Production, Carbon Capture and Sequestration : Hearing Before the Subcommittee on Energy and Environment, Committee on Science and Technology, House of Representatives, One Hundred Tenth Congress, First Session, May 15, 2007

Advances in Carbon Management Technologies comprises 43 chapters contributed by experts from all over the world. Volume 1 of the book, containing 23 chapters, discusses the status of technologies capable of yielding substantial reduction of carbon dioxide emissions from major combustion sources. Such technologies include renewable energy sources that can replace fossil fuels and technologies to capture CO2 after fossil fuel combustion or directly from the atmosphere, with subsequent permanent long-term storage. The introductory chapter emphasizes the gravity of the issues related to greenhouse gas emissionglobal temperature correlation, the state of the art of key technologies and the necessary emission reductions needed to meet international warming targets. Section 1 deals with global challenges associated with key fossil fuel mitigation technologies, including removing CO2 from the atmosphere, and emission measurements. Section 2 presents technological choices for coal, petroleum, and natural gas for the purpose of reducing carbon footprints associated with the utilization of such fuels. Section 3 deals with promising contributions of alternatives to fossil fuels, such as hydropower, nuclear, solar

photovoltaics, and wind. Chapters 19 of this book is freely available as a downloadable Open Access PDF under a Creative Commons Attribution-Non Commercial-No Derivatives 4.0 license. The links can be found on the book's Routledge web page at https://www.routledge.com//9780367198428
IPCC Report on sources, capture, transport, and storage of CO_2, for researchers, policy-makers and engineers.
The United States produces over seventy percent of all its electricity from fossil fuels and nearly fifty percent from coal alone. Worldwide, forty-one percent of all electricity is generated from coal, making it the single most important fuel source for electricity generation, followed by natural gas. This means that an essential part of any portfolio for emissions reduction will be technology to capture carbon dioxide and permanently sequester it in suitable geologic formations. While many nations have incentivized development of CCS technology, large regulatory and legal barriers exist that have yet to be addressed. This book identifies current law and regulation that applies to geologic sequestration in the U.S., the regulatory needs to ensure that geologic sequestration is carried out safely and effectively, and barriers that current law and regulation present to timely deployment of CCS. The authors find the three most significant barriers to be: an ill-defined process to access pore space in deep saline formations; a piecemeal, procedural, and static permitting system; and the lack of a clear, responsible plan to address long-term liability associated with sequestered CO_2. The book provides legislative options to remove these barriers and address the regulatory needs, and makes recommendations on the best options to encourage safe, effective deployment of CCS. The authors operationalize their recommendations in legislative language, which is of particular use to policymakers faced with the challenge of addressing climate change and energy.
CO_2 Separation from Coal-fired Power Plants by Regenerable $Mg(OH)_2$ Solutions
Integrating Technology, Monitoring, Regulation
Carbon Capture and Storage
Carbon Dioxide Removal from Coal Power Plants
Carbon Dioxide Sequestration in Geological Media