

International Cooperation on CCS Technology



Scott M. Smouse

International Coordination Team Leader
National Energy Technology Laboratory

Expert Group Meeting: Carbon Capture and
Storage and Sustainable Development

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Division for Sustainable Development

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Modes for CCS Cooperation are Many and Varied

- **Formal**

- Bilateral RD&D agreements
- Multilateral agreements (e.g., IEA, APEC, APP/AP6)
- Membership organizations (e.g., CSLF, FutureGen Alliance)
- Industrial RD&D cooperation with or without govt. participation
- U.S. government cooperates through many mechanisms:
 - CRADAs, financial assistance (contracts, grants, cooperative agreements), bilateral and multilateral cooperation agreements

- **Informal**

- Information meetings and site visits for foreign delegations
- Joint conferences, seminars, and symposium



U.S. CCS Activities with International Cooperation

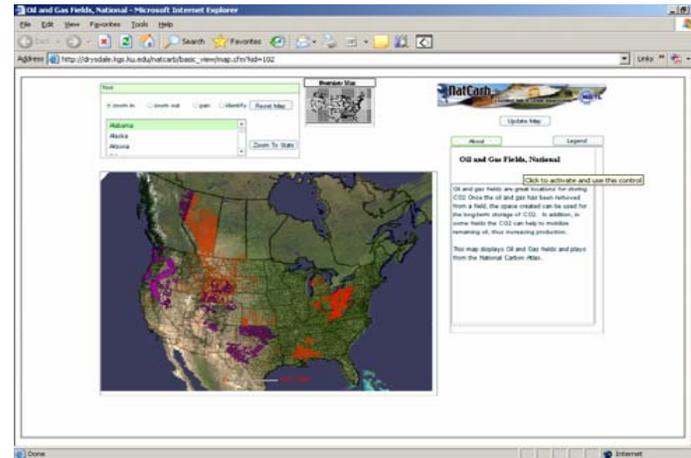


U.S. Carbon Sequestration Regional Partnerships

“Developing the Infrastructure for Wide-Scale Deployment”

Phase I (Characterization)

- 7 Partnerships (40 states)
- 24 months (2003 – 2005)



Phase II (Field Validation)

- 4 years (2005 – 2009)
- All seven Phase I partnerships continued
- \$100 million federal funds
- \$45 million cost share

Phase III (Deployment)

- 10 years (2008 – 2017)
- Several large-scale injection tests



U.S. Regional Carbon Sequestration Partnerships

Phase II Validation Tests - Injecting between 750 – 525,000 tons of CO₂

REPRESENTING:

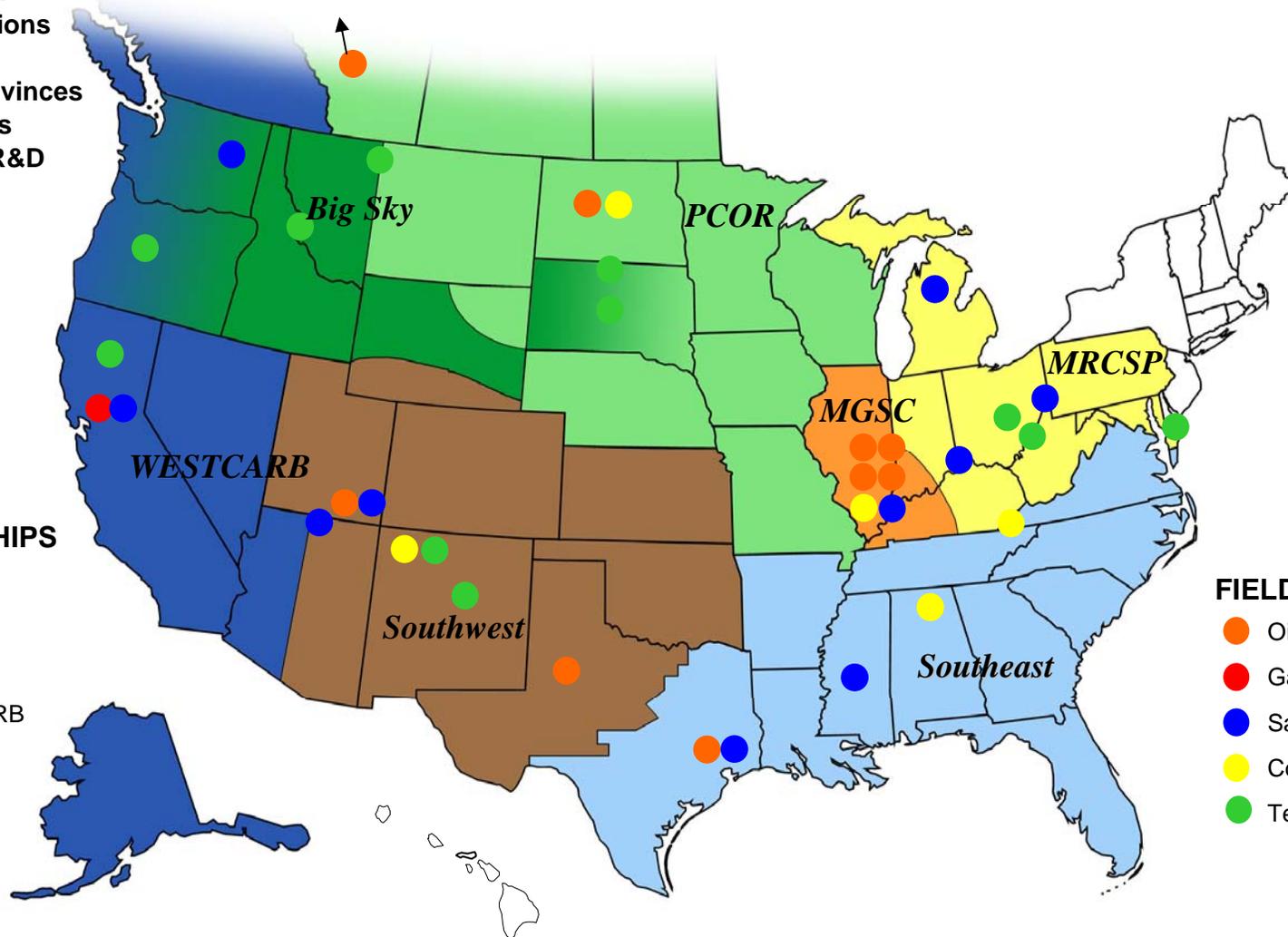
- >300 Organizations
- 40 States
- 4 Canadian Provinces
- 3 Indian Nations
- Many Foreign R&D Organizations
- 34% cost share

PARTNERSHIPS

- MRCSP
- MGSC
- SECARB
- SRCSP
- WESTCARB
- Big Sky
- PCOR

FIELD TEST TYPE

- Oil bearing (9)
- Gas bearing (1)
- Saline aquifer (10)
- Coal seam (5)
- Terrestrial (11)



U.S. Regional Carbon Sequestration Partnerships

Many foreign partners in some partnerships

- **West Coast Regional Carbon Sequestration Partnership**
 - Air Liquide, British Columbia Ministry of Energy and Mines, Det Norske Veritas
- **Southwest Regional Partnership for Carbon Sequestration**
 - Det Norske Veritas, Shell
- **Big Sky Regional Carbon Sequestration Partnership**
 - Christian Michelsen Research AS, Det Kongelige, Institute de Physique du Globe de Paris, Institute for Energy Technology, National Geophysical Research Institute, Norwegian University of Science and Technology, Research Council of Norway, Russian Academy of Sciences, Semiarid Prairie Agricultural Research Centre, SINTEF Petroleum Research, Wageningen Universiteit



U.S. Regional Carbon Sequestration Partnerships

Many foreign partners in some partnerships

- **Plains CO₂ Reduction Partnership**

- Advanced Geotechnology, Inc., Alberta Department of Energy, Alberta Energy and Utilities Board – Geological Survey, Apache Canada Ltd., British Columbia Ministry of Energy and Mines, Ducks Unlimited Canada, Enbridge, Environment Canada, MEG Energy Corporation, Natural Resources Canada, RPS Canada, Saskatchewan Industry and Resources, SaskPower, Shell Canada Energy, Suncor Energy, University of Alberta

- **Midwest (Illinois Basin) Regional Carbon Sequestration Partnership**

- British Petroleum

- **Southeast Regional Carbon Sequestration Partnership**

- CO₂ Capture Project



U.S. Bilateral CCS Cooperation

- **U.S.-China Fossil Energy Cooperation Protocol**
 - Annex IV: Energy & Environmental Control Technologies
 - 1st CO₂ Emissions Science & Technology Control Symposium (Hangzhou, 2001) with DOE and MOST as organizers
 - 2nd CO₂ Emissions Science & Technology Control Symposium (Hangzhou, Dec. 2007) with Zhejiang and Columbia Universities as organizers
- **National Energy Technology Laboratory – Korea Institute of Energy Research (NETL-KIER) MoU**
 - Renewed previous 20+ year formal cooperation (Sept. 2007)
 - Joint R&D
 - Researcher exchange
 - Focus on gasification, materials, and carbon management (CO₂ capture, chemical looping)
 - Approved APP project



U.S. Bilateral CCS Cooperation

- **New NETL Agreements to be Signed Soon with planned CCS cooperation**
 - Brazil
 - Brazilian Coal Association (SNIEC)
 - Pontifical Catholic University
 - Petrobras
 - Poland
 - Central Mining Institute + Institute for Chemical Processing of Coal
- **New Agreement under Consideration with proposed CCS cooperation**
 - India: National Thermal Power Cooperation



U.S.-led International CCS Activities

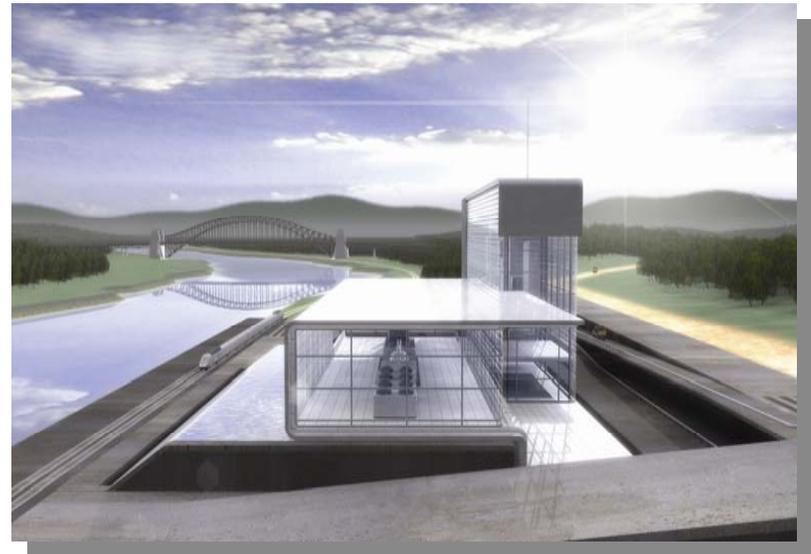


FutureGen: A Global Partnership Effort

“One-billion dollar, 10-year project to create world’s first coal-based, zero-emission electricity and hydrogen plant”

President Bush, 27 February 2003

- Research platform to accelerate deployment of promising technologies
- Broad participation from mining and electricity sectors
- 12 member industry-led consortium with international collaboration



FutureGen Project

Supporting FutureGen is Major Goal of USDOE's FE R&D Programs

- **Industry-led alliance with government oversight**

- Signed Cooperative Agreement with DOE on 2 Dec. 2005
- Project structuring to Jan. 2007
- Design to July 2009
- Construction to July 2012
- Operations to July 2016
- Site monitoring to July 2018

- **International Participation:**

- India and South Korea signed Protocols of Intent to join
- China and Japan expressed strong interest in joining

- **Industry will choose project site and backbone technologies**

- Down selected to 4 potential sites



Carbon Sequestration Leadership Forum (CSLF)

- **International climate change initiative established in 2003 focused on development of improved, cost-effective technologies to separate and capture CO₂ for its transport and long-term safe storage**
- **Chair: United States**
- **22 Members**
 - 14 Developed Country Members + European Commission
 - Australia, Canada, Denmark, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Saudi Arabia, South Korea, United Kingdom, United States
 - 7 Emerging Country Members
 - Brazil, China, Colombia, India, Mexico, Russia, South Africa



CSLF Policy Group

- **Chair: United States**
- **Vice Chairs: United Kingdom and South Africa**
- **Strategic Plan**
 - Policy and Legal Framework
 - Financing
 - Public Awareness and Acceptability
 - Stakeholder Involvement
- **Task Force for Capacity Building in Emerging Economies**
 - Chair: United States
 - Members: Australia, Canada, Colombia, Italy and Mexico
 - Initial Workshop in Pittsburgh, PA, on May 7-11, 2007
 - 48 attendees from Brazil, Colombia, India, Mexico, and South Africa, along with representatives from Saudi Arabia
 - Workshops planned for Saudi Arabia and South Africa
 - Developing 2-year action plan



CSLF Technical Group

- **Chair: United States**
- **Vice Chairs: Canada and India**
- **Work Areas:**
 - Identify key technical, economic, environmental, and other issues related to improved technological capacity
 - Identify potential areas of multilateral collaboration
 - Foster collaborative RD&D projects reflecting Members' priorities
 - Assess regularly progress of collaborative projects and make recommendations to Policy Group on direction of such projects
 - Establish and regularly assess inventory of needed research
 - Facilitate technical collaboration among international research community, academia, industry, government, and non-governmental organizations



International CCS Activities



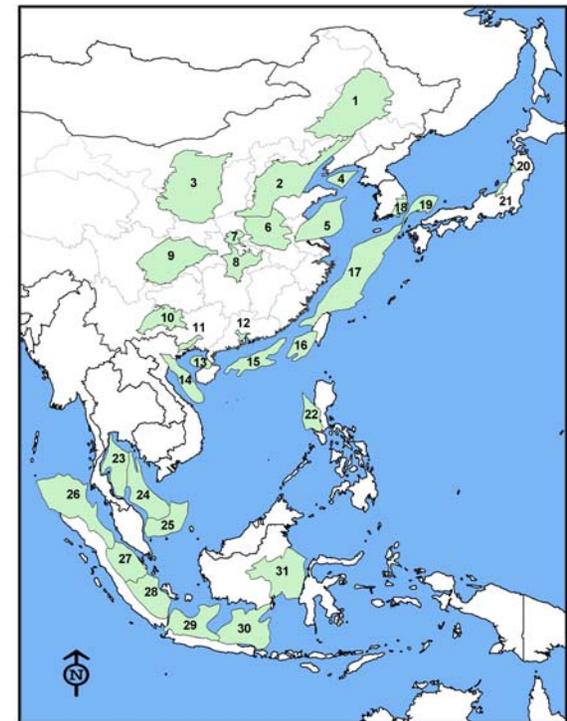
Asia Pacific Economic Cooperation (APEC)

- **Established in 1989 with 12 members, and later expanded to 21 current members:**
 - 10 developed member economies: Australia, Canada, Japan, Republic of Korea, New Zealand, Russian Federation, Singapore, Chinese Taipei, and United States
 - 11 developing member economies: Brunei Darussalam, Chile, China, Hong Kong, Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, Republic of the Philippines, and Vietnam
- **Premier forum for facilitating economic growth, cooperation, trade, and investment in Asia-Pacific region**
- **Only intergovernmental organization in world operating on basis of non-binding commitments, open dialogue, and equal respect for views of all participants**
- **CCS activities under Energy Working Group/Expert Group on Clean Fossil Energy**



APEC GeoSequestration Project

- **Phase I - Assessment of Geologic Storage Potential for CO₂ in APEC Region**
 - Completed by Australian Cooperative Research Centre on CO₂ (CO2CRC) – December 2004
 - Identified and analyzed 31 sedimentary basins in Southeast Asia from available English language references and data
 - Widely referenced as first analysis of region's opportunity to sequester CO₂



APEC GeoSequestration Project

- **Phase II – Capacity Building for Assessment of Geologic Storage Potential for CO₂ in APEC Region**
 - Completed by Delhi Group (Canada) and Alberta Research Council (Canada) with support from Cooperative Research Centre on CO₂ (CO2CRC) (Australia) – March 2005
 - 2-day capacity building workshop (Seoul, Korea/Jan. 20-21, 2005) – the first in the region
 - Approximately 120 participants from government, industry, and academia
 - Held in conjunction with 1st International Symposium on CO₂ Reduction & Sequestration



APEC GeoSequestration Project

- **Phase III**

- Revise Phase II training modules based on feedback from initial training in Korea
- Delivered training in 2 additional APEC Economies
 - China (October 2006)
 - Mexico (May 2007)

- **Phase IV**

- 2 additional training workshops
 - Proposed for China
 - Possible cooperation with CSLF Capacity Building Task Force?



International Energy Agency (IEA)

- **Established in 1974 in response to oil crises**
 - Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States
- **Clean Coal Centre**
 - Publishes survey reports on technologies, markets, and issues
 - Several reports on zero emission technologies and CCS
- **Greenhouse Gas R&D Programme**
 - Evaluation of technologies aimed at reducing GHG emissions
 - Promotion and dissemination of study results and data
 - Facilitating practical RD&D demonstration activities



Asia Pacific Partnership on Clean Development and Climate (APP)

- **Innovative *voluntary* partnership to address clean development, energy security, and climate change through accelerated development and deployment of clean energy technologies**
 - Builds on existing bilateral and multilateral initiatives to enhance cooperation while recognizing differing national circumstances
- **Established in July 2005**
- **Members: Australia, China, India, Japan, Korea, and United States**
- **Eight Task Forces**
 - Aluminum
 - Buildings & Appliances
 - Cement
 - Cleaner Fossil Energy
 - Coal Mining
 - Power Generation & Transmission
 - Renewable Energy & Distrib. Generation
 - Steel



Approved APP CFE Task Force Projects

- **CO₂ Capture and Storage Program Project (Australia)**
 - Researchers and senior officials from APP Partner countries will visit CCS projects in Australia
 - Project supports capacity building, knowledge transfer, education, and training
 - Staged project across full CCS cycle:
 - Site selection
 - Technical risk assessment
 - Characterization
 - Monitoring
 - Measurement
 - Verification



Approved APP CFE Task Force Projects

- **CO₂ Enhanced Coal Bed Methane (CSIRO-JCOAL-ECBM) Project (Australia, Japan, China)**
 - Validate (and, if appropriate, modify and improve) use of CO₂ injection in coal seams to enhance methane recovery
 - Initial field trials in Australia
 - Subsequent field trials in China
- **Project builds on earlier work by JCOAL of Japan**
- **Project outcomes could be used to guide larger CO₂ sequestration projects**



Proposed APP CFE Task Force Projects

- **Wyoming State and Shanxi Province CCS Partnership**
 - Initiate CCS cooperation between top U.S. coal producing state, Wyoming, and top Chinese coal producing province, Shanxi
 - First year efforts will focus on relationship building and short-term researcher exchanges
 - Leading Chinese R&D organizations in other parts of the country will participate but focus on assessing opportunities for CCS in Shanxi
 - Other leading U.S. organizations involved in regional CCS cooperation with Wyoming may also be involved
- **U.S./China Young Scientist & Engineering Leadership Program – Columbia University**
 - Foster technical communications between young graduate and post-doctoral scientists working on CCS research in U.S. and China
 - First-year efforts to focus on relationship building and short-term researcher exchanges



Proposed APP CFE Task Force Projects

- **Carbon Storage Project in India – Columbia University**
 - Carbon storage options for an IGCC project with Andhra Pradesh Power Generation Corporation (APGENCO)
 - ‘Academic’ analysis of potential for geological carbon sequestration in Andhra Pradesh State
 - Coordinate with ongoing efforts of APGENCO to develop 125-MW IGCC plant in cooperation with Bharat Heavy Electricals, Ltd. (BHEL)
 - Columbia University will work with APGENCO and National Geophysical Research Institute on site characterization and analysis of pilot injection projects



G8/IEA/CSLF Workshops on Near-Term CCS Opportunities

- **Response to G8 Gleneagles Communiqué (July 2005)**
 - *...accelerate development and commercialization of CCS technology*
 - *...hold workshops on short-term opportunities for CCS in fossil fuel sector, including EOR and CO₂ removal from natural gas*
- **Workshop Topics**
 - Technical Issues
 - Commercial/Financial Issues
 - Legal and Regulatory Issues
 - Public Education and Outreach Issues
 - International Mechanisms
- **Three workshops on near-term opportunities**
 - Issues and Opportunities Workshop
 - Assessment Workshop
 - Recommendations Workshop



G8-IEA-CSLF Workshops on Near-Term CCS Opportunities

- **Issues and Opportunities Workshop (USA, August 2006)**
 - Assess opportunities, barriers, required policies, concerns, lessons to be learned from existing projects
- **Assessment Workshop (Norway, June 2007)**
 - Consider options for embarking on and advancing near-term opportunities and conditions necessary for deployment of CCS
 - Develop options to address these issues
 - Provide timeframes for feasible implementation of these options
- **Recommendations Workshop (Canada, November 2007)**
 - Develop recommendations for presentation by IEA and CSLF to G8 meeting scheduled for Japan in 2008
 - Consider, evaluate, and compare findings, options, and timeframes developed in earlier workshops from policy and stakeholder perspectives
 - Attempt to facilitate grounds for consensus among different perspectives
 - Provide policy recommendations for early implementation of CCS, including further international collaboration



EU/UK/China nZEC Project

- **CCS integrated as leading-edge technology into China's “*National Medium and Long-term Science and Technology Development Plan towards 2020*”**
- **Under China's 11th 5-Year Plan (2006-2010), National High Technology Program supports CCS development**
- **Near-Zero Emissions Coal (nZEC) Initiative announced at EU-China Summit in September 2005 as part of EU-China Partnership on Climate Change**
 - Significantly reduce cost of key energy technologies, promoting their distribution and operation
 - Develop and demonstrate advanced nZEC technology with CCS in China and EU
 - Centerpiece of Partnership is collaboration to demonstrate potential for nZEC and CCS in China



Other International CCS Projects

- **ENhanced CAPture of CO₂ Project (ENCAP)**

- Provide pre-combustion decarbonization technologies for large power plants with objective of achieving at least 90% capture and a 50% capture cost reduction
- Partners include Air Liquide, Alstom Switzerland, Alstom Power Boiler, Alstom Power Centrales, Alstom Power, BOC, Centre for Research and Technology Hellas, Chalmers Tekniska Högskola, Deutsches Zentrum für Luftund, Raumfahrt, ENERGI E2 A/S, Institut Français du Pétrole, Linde, mg engineering Lurgi Oel Gas Chemie, Mitsui Babcock Energy, Netherlands Organisation for Applied Scientific Research, Public Power Corporation, RWE Power, Siemens, SINTEF Energiforskning, SINTEF Stiftelsen för industriell og teknisk, forskning ved Norges Tekniske Högskole, Statoil ASA, Norges Teknisk-Naturvitenskapelige Universitet, Universität-Gesamthochschule Paderborn, Universität Stuttgart, Universiteit Twente, University of Ulster



Other International CCS Projects

- **CO₂ Capture and STORage Project (CASTOR)**

- Develop absorption liquids for post-combustion capture with low energy consumption at 90% recovery rates
- Participants include Alstom Power Centrales, BASF, Bundesanstalt für Geowissenschaften, und Rohstoffe, Bureau de Recherches Géologiques, et Minières, Elsam, ENERGI E2, Enil Technologie, Gaz de France, Geological Survey of Denmark and Greenland, GVS, Imperial College of Science, Technology and Medicine, Istituto Nazionale di Oceanografia, e di Geofisica Sperimentale, Mitsui Babcock Energy Ltd, Natural Environment Research Council, Netherlands Organisation for Applied, Scientific Research, Norwegian University of S&T, Powergen/E.ON Engineering, Public Power Corporation, Repsol Investigaciones Petrolíferas, Rohöl Aufsuchungs, RWE Power, Siemens, SINTEF – Energy Research, SINTEF – Stiftelsen for Industriell, og Teknisk Forskning ved Norges, Tekniske Högskole, SINTEF Petroleumsforskning, Statoil, Universität Stuttgart, Universiteit Twente, Vattenfall



Other International CCS Projects

- **Carbon Dioxide Capture and Hydrogen Production from Gaseous Fuels Project (CACHET)**

- Develop and reduce cost of technologies for deep (~90%) reductions in CO₂ emissions from H₂ production from natural gas
- Partners include Air Products, Alstom Power Boilers, Chalmers University of Technology, Chevron Energy Technology, ConocoPhillips, Consejo Superior de Investigaciones Científicas, Dalian Institute of Chemical Physics, E.ON UK, Electricity Authority of Cyprus, Endesa Generación, Energy Research Centre of the Netherlands, EniTecnologie, Fraunhofer UMSICHT, Institut Francais du Pétrole, Institute for Ecology of Industrial Areas, Meggitt, National Technical University of Athens, Norsk Hydro, Petroleo Brasileiro, Process Design Centre – Shell International Renewables, Siemens, SINTEF/Stiftelsen for Industriell og Teknisk, Forskning ved Norges Tekniske Hogskole, Suncor Energy, Technical University of Sofia, Technip France, Technische Universität Wien



Other International CCS Projects

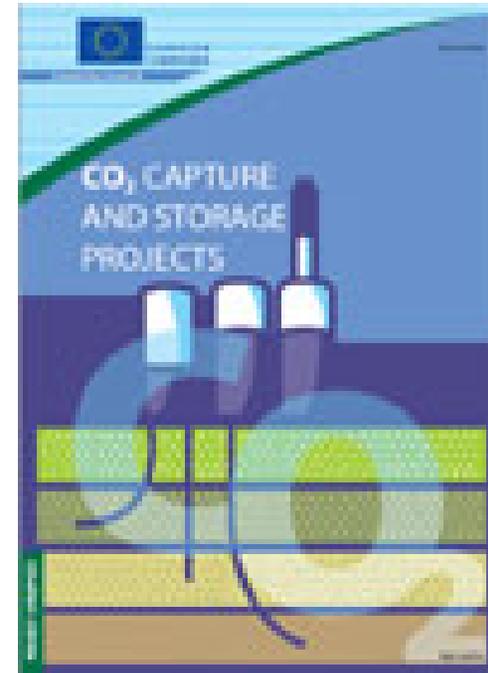
- **CO2SINK Project**

- In-situ testing of geological storage during injection of 10-30 kilotonnes/yr of pure CO₂ into reservoir over 2 years
- Detailed laboratory tests of rocks, fluids, and micro-organisms and in-situ measurements and experiments in boreholes
- Partners include Det Norske Veritas, E.ON Energie, GEOS Freiberg Ingenieurgesellschaft, Geological Survey of Denmark and Greenland, IEA Greenhouse Gas R&D Programme, Mineral and Energy Economy Research Institute, RWE Power, Schlumberger Carbon Services, Shell International Exploration and Production, Siemens Power Generation, Statoil, University of Kent, Universität Stuttgart, Uppsala University, Vattenfall Europe Mining, Verbundnetz Gas, Vibrometric Oy Cosma



Other International CCS Projects

- **EC Report on CO₂ Capture and Storage Projects by the Directorate-General for Research Sustainable Energy Systems (2007, EUR 22574/ISSN 1018-5593)**
 - provides brief descriptions on 18 EC-funded projects



Additional CCS Projects with International Participation

- **CO₂ Capture, Transport and Storage in the Netherlands Project (CATO)**
 - Predominately Netherlands' network that includes Shell and World Wildlife Fund, assessing and developing new knowledge, technologies, and approaches to identify whether and how CCS can contribute to sustainable energy system in the Netherlands
- **Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)**
 - Australian federal & state government and industry supported R&D organization with participation of Chevron, ConocoPhillips, Meiji University, New Zealand Resource Consortium, Schlumberger, Shell, and URS Corporation
- **European Technology Platform on Zero Emission Fossil Fuel Power Plants (ETP ZEP)**
 - Established by European Commission, European energy industry, research community and NGOs to unite all key stakeholders.
 - Members include BP Alternative Energy International Ltd., Shell International Renewables B.V., Statoil, Total SA, and VGB Powertech e.V.



International CCS Technology Cooperation Summary

- **Significant CCS technology RD&D underway**
 - Most RD&D in developed countries (Australia, Europe, Japan, Korea, United States)
 - Extensive cooperation among European countries
 - Limited, but increasing, formal RD&D cooperation between U.S. and other countries but leadership on CSLF, APP, APEC and FutureGen
 - Little cooperation between emerging/developing and developed countries relative to developed country cooperation
 - Lack of quid pro quo RD&D opportunities
 - Focused mainly on capacity building, but may lead to joint RD&D in the future
- **Significant future CCS RD&D and capacity building needs**
 - Better leverage our existing programs and resources
 - More resources are needed, especially to engage China, India, and other coal-dependent countries



Our Continuing Challenge

Increased....

- **Communication**
- **Collaboration/Cooperation**
- **Coordination**
- **Commitment**

....are critical if we are make progress!

