



# Opportunities for CO<sub>2</sub> Capture and Storage

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# CO<sub>2</sub> Capture and Storage

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## *Introduction*

- To determine the opportunities for CO<sub>2</sub> capture and storage, need information on distribution of:
    - CO<sub>2</sub> emission sources
    - Geological formations for storage
  - Then can identify the best matches between CO<sub>2</sub> emission sources and storage reservoirs
  - By considering the purity of the CO<sub>2</sub> emissions
    - Can rank the options for capture
    - High purity sources present early opportunities
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# CO<sub>2</sub> Capture and Storage

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## *Structure of the Presentation*

- Inventory of emission sources
  - Matching high purity sources with storage opportunities
    - Aim to identify the “early opportunities”
  - Matching low purity sources with storage opportunities
  - Web site and database of practical R&D projects worldwide
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# Inventory of Emission Sources

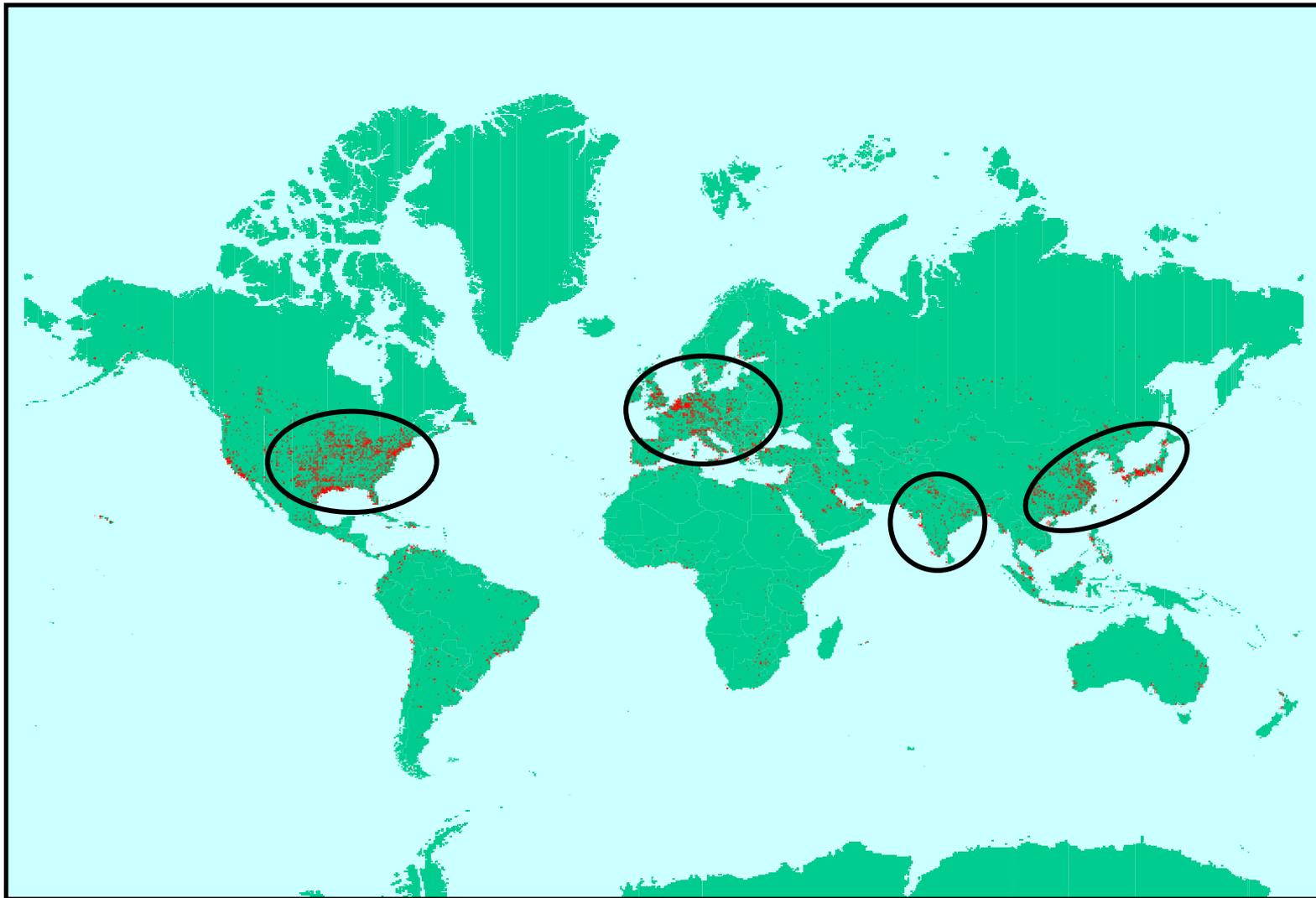
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## *CO<sub>2</sub> emission sources*

- IEA GHG developed database of CO<sub>2</sub> emission sources
  - Database contains 14 641 entries
  - Each entry is a single plant
    - Plant name
    - Location
    - Longitude and Latitude co-ordinates
    - CO<sub>2</sub> emission data (volumes & concentration)
  - Emission baseline is year 2000
  - Total CO<sub>2</sub> emissions = 13.44 Gt/y
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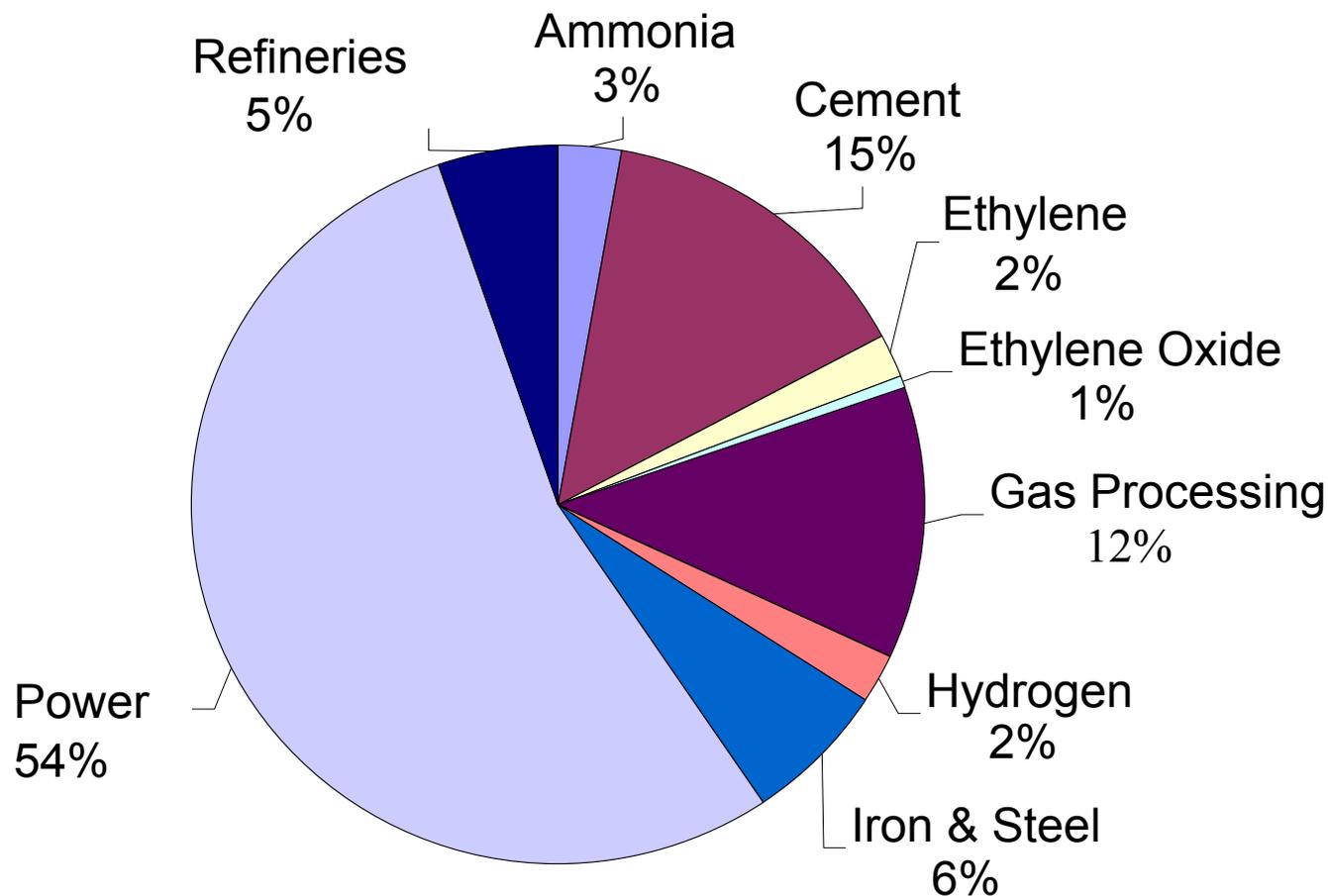
# Distribution of CO<sub>2</sub> Emissions



# CO<sub>2</sub> Emission Sources



## *Sectoral distribution of sources*



# Inventory of Emission Sources

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## *High purity sources*

- Offer a low cost for capture
  - Several processes can generate high purity CO<sub>2</sub> emissions
    - Gas processing plant
    - Hydrogen plants at refineries
    - Ethylene oxide plants
    - Ammonia Fertiliser plants
  - Over 440 potential sources identified
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# Inventory of Emission Sources

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## *High purity sources*

- 198 of these emit  $>100,000$  t CO<sub>2</sub>/y
    - Many of the others are natural gas processing plant
  - This is  $<2\%$  of total number of sources in database
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# CO<sub>2</sub> Capture and Storage



## *Early opportunities study*

- Matched:
  - High purity CO<sub>2</sub> sources
    - ◆ Low capture costs
  - Enhanced recovery projects
    - ◆ CO<sub>2</sub>-EOR<sup>1</sup> & CO<sub>2</sub>-ECBM<sup>2</sup>
    - ◆ Potential for profitable storage operations
  - Limited pipeline distances – maximum 100 km
- GIS<sup>3</sup> constructed with major oil and coal fields overlain by high purity sources

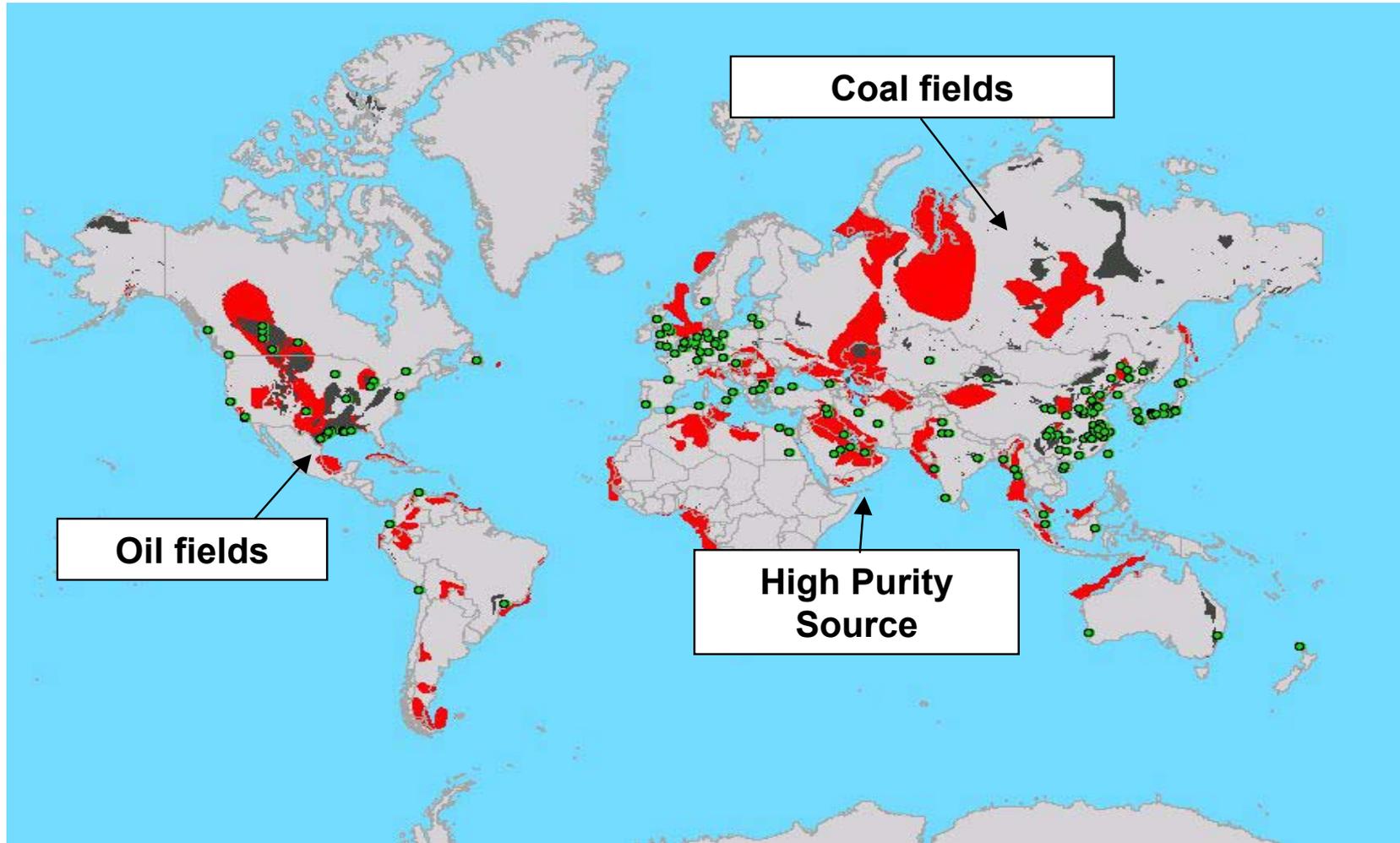
*1 Enhanced Oil Recovery*

*2 Enhanced Coal Bed Methane*

*3 Geographical Information System*

# Early Opportunities Study

## *GIS of sources and storage formations*



# Early Opportunities Study

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## *Principal features (1)*

- 198 high purity sources world wide
  - Mapping studies identified:
    - 62 sources with 409 EOR opportunities
    - 58 Sources with 78 ECBM opportunities
  - CO<sub>2</sub>-EOR Opportunities
    - 350 in North America
    - 25 Middle East & 22 in China
  - CO<sub>2</sub>-ECBM Opportunities
    - 33 in China,
    - 14 in Europe
  - Storage potential estimated at 16 Gt CO<sub>2</sub>
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# Early Opportunities Study

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## *Principal features (2)*

- Short list of 15 CO<sub>2</sub>-EOR and 15 CO<sub>2</sub>-ECBM projects developed
  - Not best technical options
  - Geographical distribution of opportunities:
    - CO<sub>2</sub>-EOR
      - ◆ Canada/USA (12) Mexico (1) & Saudi Arabia (2)
    - CO<sub>2</sub>-ECBM
      - ◆ China (9), Europe (6)
  - 4 Cases selected for more detailed study
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# Early Opportunities Study

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## *Cases studied*

- Two cases with hydrogen plants matched to CO<sub>2</sub>-EOR opportunities
    - Al-Jubail, Saudi Arabia
    - California, USA
  - Two cases with ammonia plants matched to CO<sub>2</sub>-ECBM opportunities
    - Shaanxi Province, China
    - Alberta, Canada
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# Early Opportunities Study

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## *Case study analyses*

- Mass and energy balances were developed and an initial economic analysis undertaken
  - Case specific issues were examined, which included:
    - Technical implementation (field tests, demonstration activities)
    - Financing options
    - Government policy on CO<sub>2</sub> reduction crediting
    - Regulatory issues including verification and validation of CO<sub>2</sub> credits
  - Barriers to implementation were identified.
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# Early Opportunities Study

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## *Case study analyses*

- Economic assessments
    - Net storage costs for CO<sub>2</sub>-EOR cases were:  
-\$12 to \$14/t CO<sub>2</sub>
    - Net storage costs for CO<sub>2</sub>-ECBM cases were:  
\$8 to \$13/t CO<sub>2</sub>
  - CO<sub>2</sub>-EOR projects look more attractive from an economic perspective
  - Technology more developed than CO<sub>2</sub>-ECBM
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# Early Opportunities Study

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## *Barriers to implementation*

- Carbon trading market at early stage of development
  - Limited regulatory drivers
  - Operators awareness limited
  - Technical and environmental issues need to be resolved particularly for CO<sub>2</sub>- ECBM
  - Public acceptability
  - Potential future financial liabilities
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# Early Opportunities Study

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## *Summary*

- Useful exercise to identify early opportunity options for CO<sub>2</sub> capture and storage
  - Identified a significant number of potential early opportunity cases
  - Cases studies indicate CO<sub>2</sub>-EOR to be most attractive of the early opportunity options
  - Although some barriers exist they do not represent insurmountable obstacles
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# CO<sub>2</sub> Capture and Storage

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## *Low purity sources*

- The majority of sources will be low purity >15% CO<sub>2</sub>
  - Represent the next set of opportunities
  - Many research projects worldwide are studying these opportunities
  - Research is on a regional scale
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# Matching Low Purity Sources

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## *Research project examples*

- Australia      GEODISC/CO2RCRC
  - Canada      Assessment of sources and coal seam opportunities
  - Europe      GESTCO  
CO2STORE  
CASTOR
  - Japan      CO<sub>2</sub> Sequestration project
  - USA      MIDCARB  
5 Regional Partnerships
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# Capture & Storage Website

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**Website** [www.co2sequestration.info](http://www.co2sequestration.info)

- Aims of site:
    - Information site on CO<sub>2</sub> capture and storage R&D.
    - Help promote awareness of R&D underway
    - Help facilitate cooperation between projects.
  - R&D Database
    - Currently has 81 entries (increasing to 95 soon).
    - Each entry is a current or completed project.
    - Data records from publicly available information.
    - Database updated on a six monthly basis.
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# Capture & Storage Website

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## *Website search criteria*

- Web site can be searched as follows:
    - on a regional basis using a simple world map
    - using the main categories from a pull down menu
    - using project categories such as CO<sub>2</sub>-EOR etc.
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# CO<sub>2</sub> Sequestration

## Search Research & Demonstration Projects

### Search by Project Type

Enter Keyword

Project Type

Project Category

Search

Clear



### Search by Region (Click to Select)



- Home
- What is CO2 Sequestration?
- Research Programmes
- Search Projects
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## CO<sub>2</sub> Sequestration

### Continent Search

#### Europe



#### CO<sub>2</sub> Capture Demonstration Projects

- [Other, Norsk Hydro's \*Hydrokraft\* Technology, Possibly Rogaland and Hordaland](#)

#### CO<sub>2</sub> Capture R&D Projects

- [Oxy Fuel Combustion, Advanced Zero Emissions Power Plant, N/A](#)
- [Oxy Fuel Combustion, Development of the HiOx Technology, Norway](#)

#### CO<sub>2</sub> Geological Storage Demonstration Projects

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## CO<sub>2</sub> Sequestration

### Project Details

#### Norsk Hydro's *Hydrokraft* Technology

<b>Project Type</b>	CO2 Capture Demonstration Project
<b>Project Category</b>	Other
<b>Project Overview</b>	The company has proposed a clean power generation process that initially decarbonizes natural gas, then fires the hydrogen-rich balance in commercially-available gas turbines. The concentrated CO2 stream produced can be applied to EOR operations
<b>Project Aim(s)</b>	To develop a commercially viable, environmentally-acceptable system for power generation using dilute hydrogen as fuel gas
<b>Partners/Participants</b>	Norsk Hydro plus industrial partners
<b>Funding Source(s)</b>	Governmental and industrial sources
<b>Overall Project Costs</b>	Possibly up to US \$1-1.3 billion
<b>Project Timescale</b>	Started: 1998
<b>Expected Key Deliverables</b>	Detailed technical reports Engineering studies and designs Feasibility studies Construction and testing of prototype Hydrokraft system Commercial demonstration of Hydrokraft system
<b>Project Status</b>	Active
<b>Project Links</b>	A project outline if given at: <a href="http://www2.hydro.com/konsern/news/eng/1998/980929a.html">http://www2.hydro.com/konsern/news/eng/1998/980929a.html</a>  Further details and corporate plans are presented at: <a href="http://www2.hydro.com/konsern/news/eng/1998/980423a.html">http://www2.hydro.com/konsern/news/eng/1998/980423a.html</a>

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# CO<sub>2</sub> Capture and Storage

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## *Conclusions*

- An inventory of CO<sub>2</sub> emissions sources has been developed
  - Used to identify early opportunities for CO<sub>2</sub> capture and storage
  - Work to match low purity sources is underway in many regions of the world
    - But there are gaps
  - A database and Web site on practical R&D has been developed
    - Happy for CSLF to use
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