Alberta Research Council Enhanced Coalbed Methane Recovery Project in Alberta, Canada

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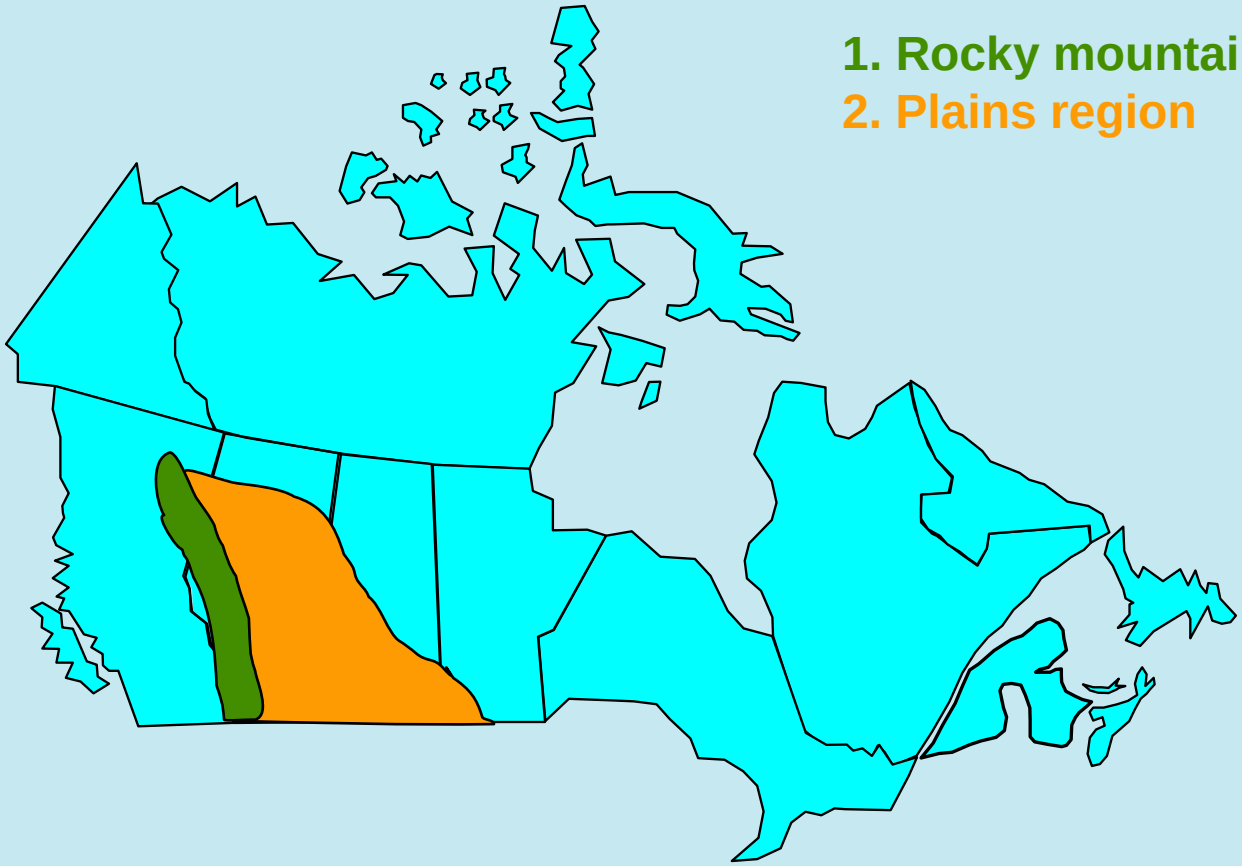
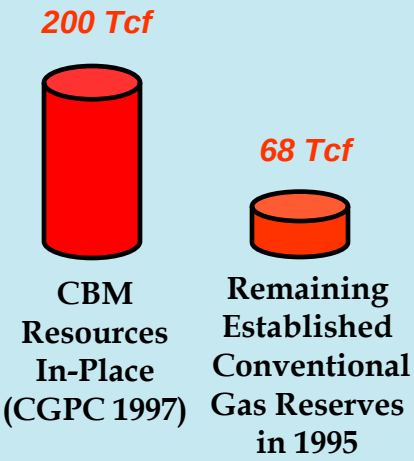
Western Canada CBM Resources



1. Rocky mountain foothills region
2. Plains region



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Background

- Alberta has an abundant CBM resource
- Little commercial production of CBM in Canada to date due to low permeabilities encountered
- Compared to EOR, ECBM does not require pure CO_2
- Injection of CO_2-rich gases into CBM reservoirs could significantly enhance recovery while trapping CO_2
- ECBM technology is at an embryonic stage of development but shows commercial potential

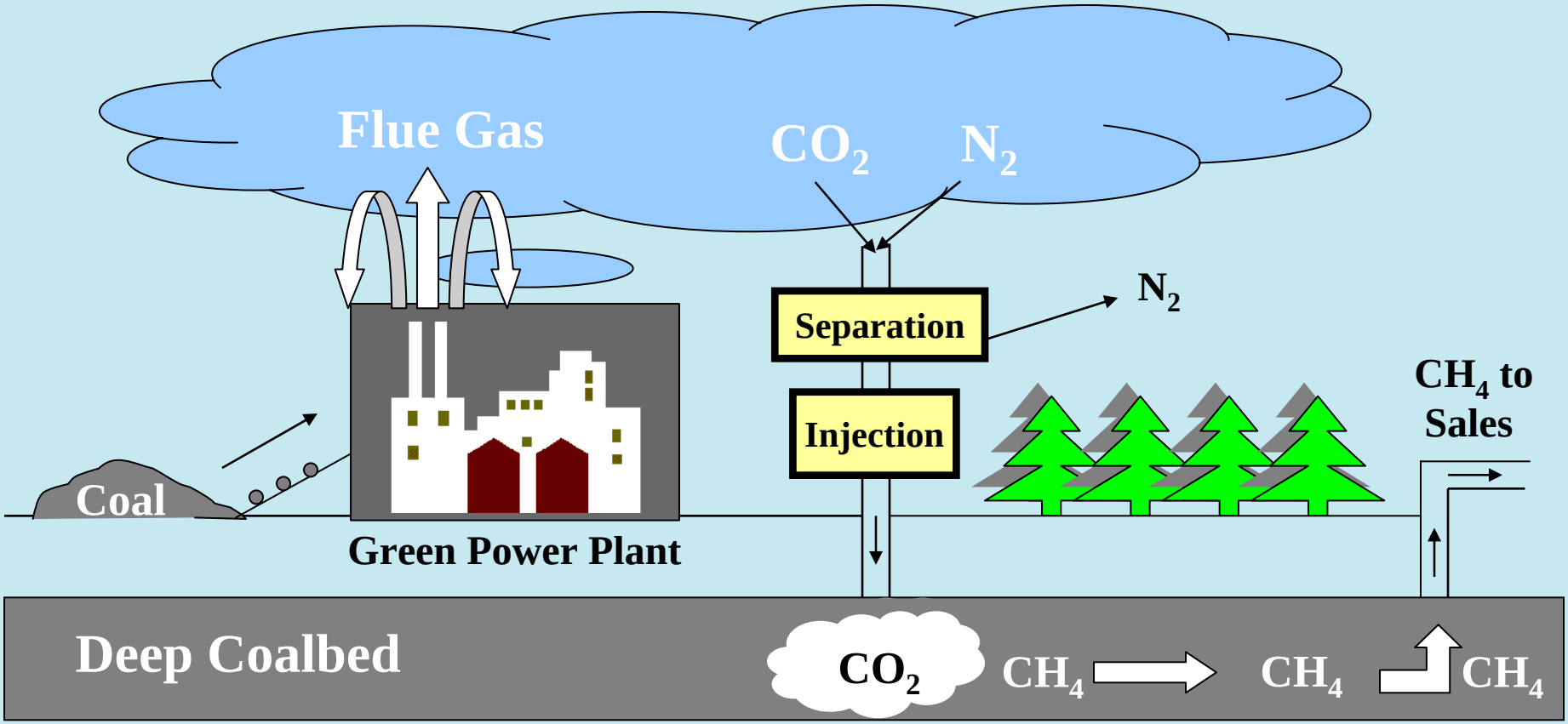
Coalbed Methane Recovery in Canada

- At the present time, few large-scale commercial recovery projects
- In general, Alberta coals have very low permeability compared to San Juan Basin coals
- Gas production rates are low
- Needs enhanced coalbed methane (ECBM) recovery technology to improve to economical recovery rates

Overall Objectives of Project

- Use CO_2 to enhance coalbed methane (CBM) recovery factors and production rates in Alberta, Canada
- Reduce greenhouse gas (GHG) emissions by subsurface injection (storage) of CO_2 into coalbeds

Alberta Research Council (ARC) ECBM Recovery Project



- **Enhanced coalbed methane (ECBM) recovery**
- **Sequestration of CO_2**

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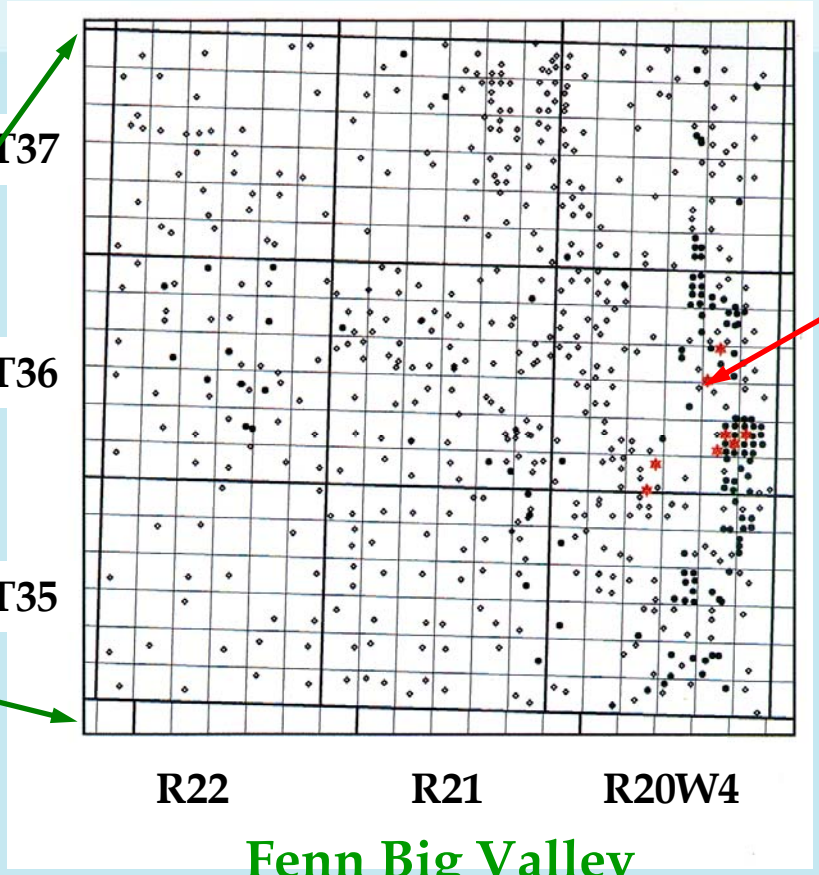
Current Participants

- Air Liquide Canada
- Alberta Geological Survey
- Alberta Energy Research Institute (AERI)
- BP
- ConocoPhillips
- Dow Chemical
- Environment Canada
- Geological Survey of Canada
- IEA Greenhouse Gas R&D Programme
- Japan Coal Energy Center
- Natural Resources Canada
- Japan Coal Energy Center
- Netherlands Institute of Applied Geosicence (TNO)
- Saskatchewan Industry and Resources
- Sproule International
- Suncor Energy Inc.
- Tesseract Corporation (U.S.A.)
- United Kingdom Department of Trade and Industry
- United States Department of Energy
- University of Alberta

Micro-Pilot
Fenn Big Valley,
(Central Alberta, Canada)



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Micro-Pilot Goals

- Accurate measurement of injection and production behavior for single well
- Estimate reservoir properties and sorption behavior
- Calibrate numerical models based on history matching of field data
- Forecast expanded pilot or full-field development production

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Single Well CO_2 Injection Test

Downhole P/T Monitoring

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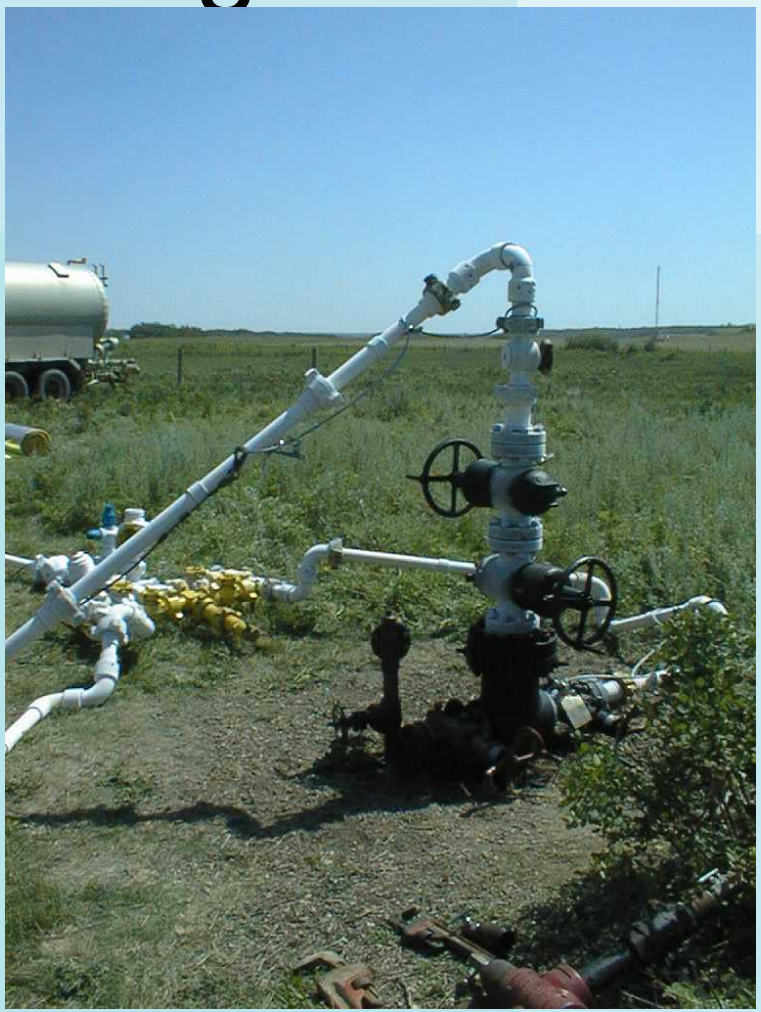
Single Well CO_2 Injection Test



CO_2 Injection

Gas Production Monitoring

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Micro-Pilot Test Summary

- All single well micro-pilot tests were successful
- Coal characterization completed
- CO_2 sequestration in coalbed is feasible
- High quality data base available for numerical model validation
  - Injection & production rates
  - Composition vs. time
  - Bottom-hole pressure & temperature

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Phase IV Tasks

- Integrate CO_2 waste stream sources with potential ECBM reservoirs
- Laboratory testing of CBM reservoir response to sorption/desorption process of gaseous waste streams
- Improvement of ECBM numerical reservoir simulators through history matching and their use for prediction
- Economic evaluation of novel surface and ECBM recovery technologies to optimize the ECBM process for low permeability reservoirs

Phase IV: Matching Sources and Sinks

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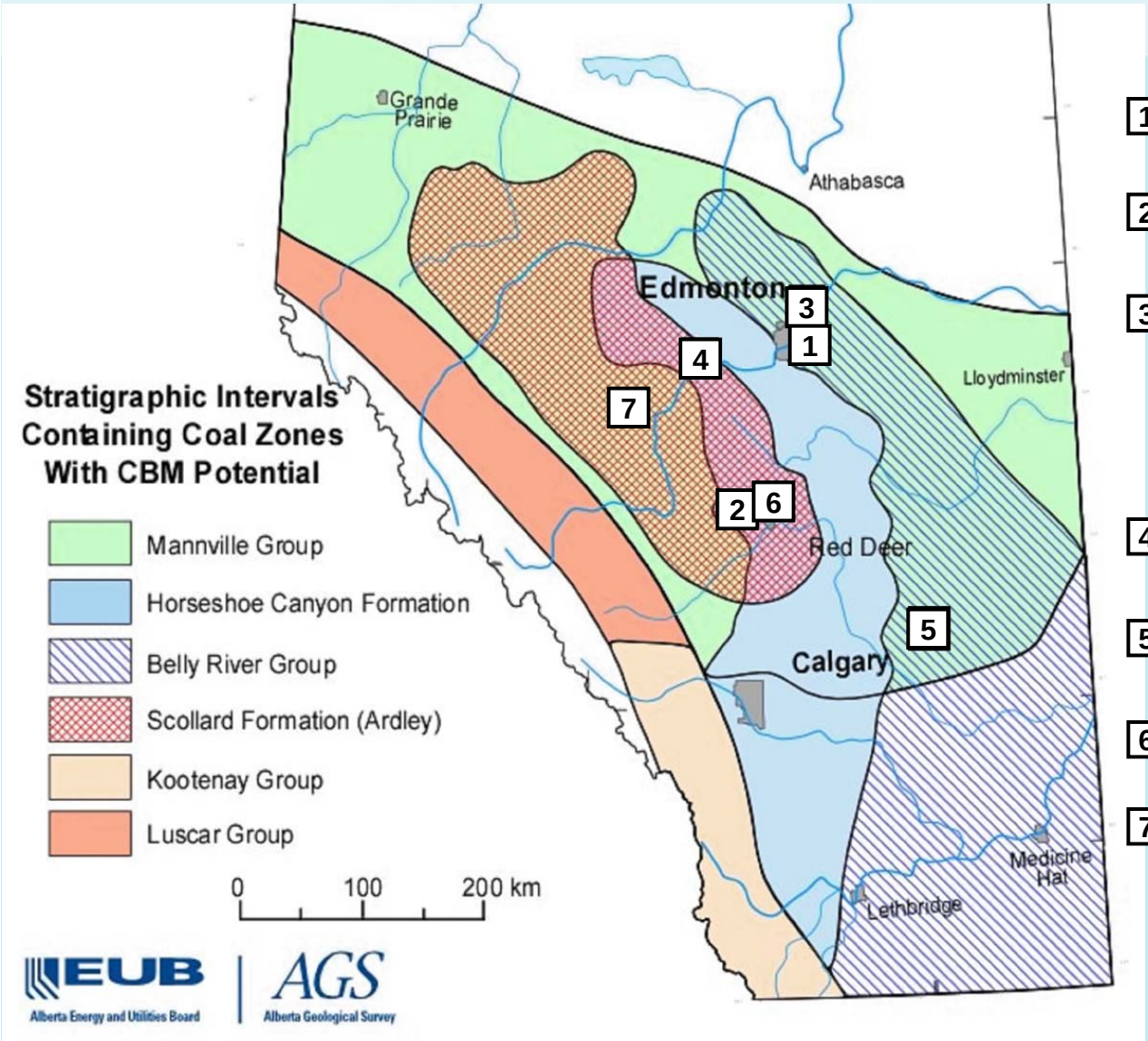

1. **Landfill Gas**
2. **Ethanol Plant**
3. **Ethane Plant, Ethylene Oxide Plant, Refinery, Ammonia Plant, Cogeneration Plant**
4. **Coal-Fired Power Plant**
5. **Coal-Fired Power Plant**
6. **Ethylene Oxide Plant**
7. **Acid Gas Plant**

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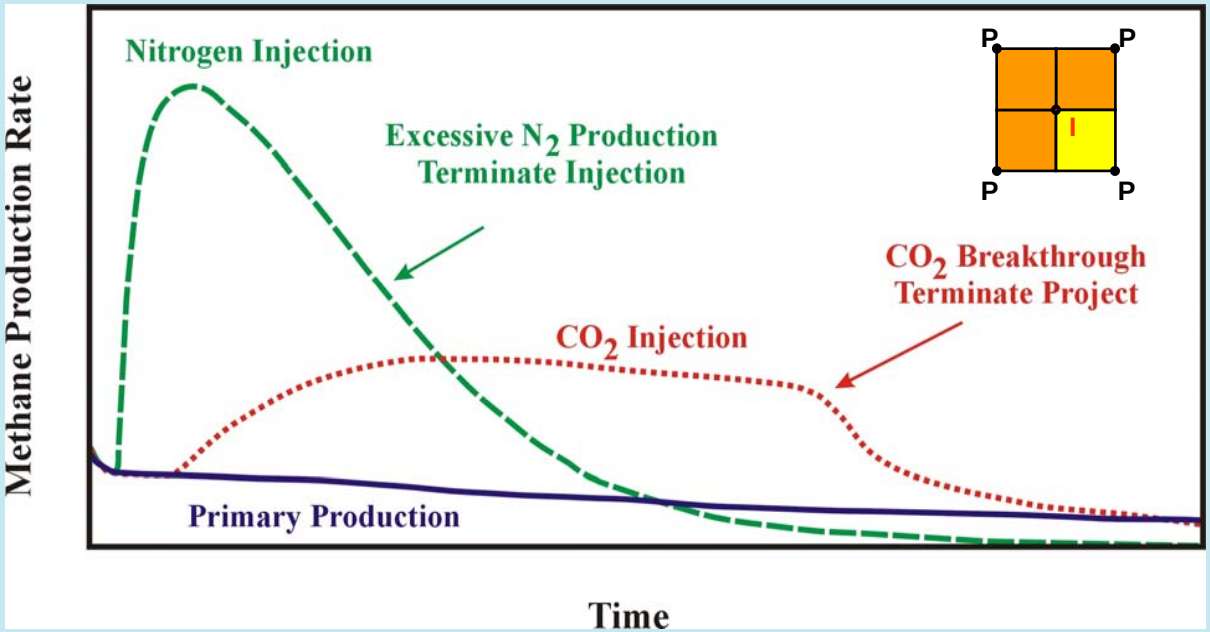
Alberta ECBM Phase IV

- Identifying optimum mixture of CO_2 and N_2 and other waste gas streams for enhanced CBM production



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Forecast Full-Field Development Production

Numerical Modelling - 5-Spot Pattern

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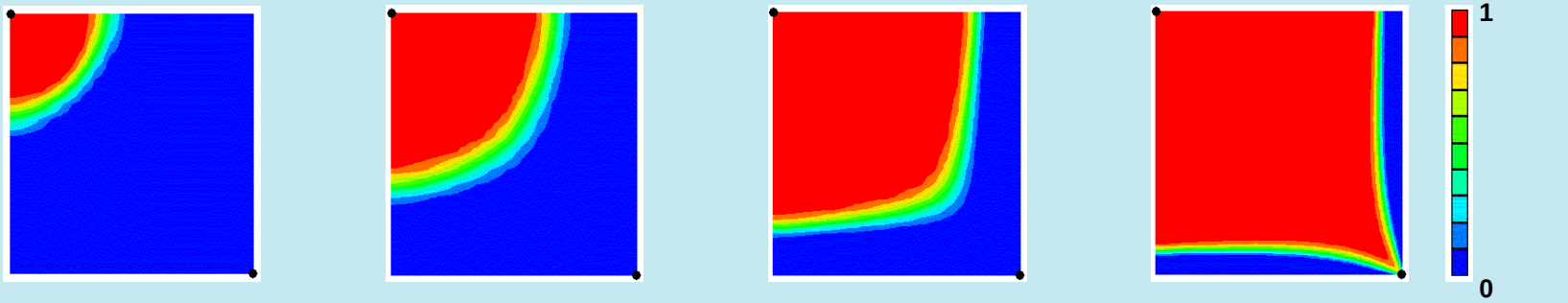
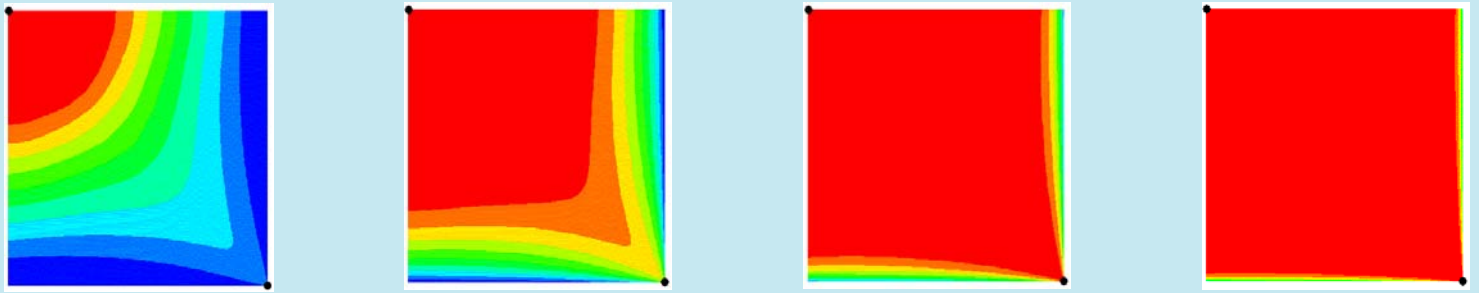
CO_2 Injection



N_2 Injection



After 1 year | After 3 years | After 5 years | After 7 years

1/4 of 5-Spot Pattern

Constant Injection Rate

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CO_2-ECBM Phase V Objectives

1. To execute CO_2-ECBM multi-well pilots in the Ardley, Horseshoe Canyon and Mannville coals
2. Run micro-pilots to optimize design for multi-well pilot
3. Methodologies and theory developed for exploitation of CO_2 storage and enhanced methane production

Note: *this project may interface with another project aimed at Enhancing Permeability in Tight Reservoirs*

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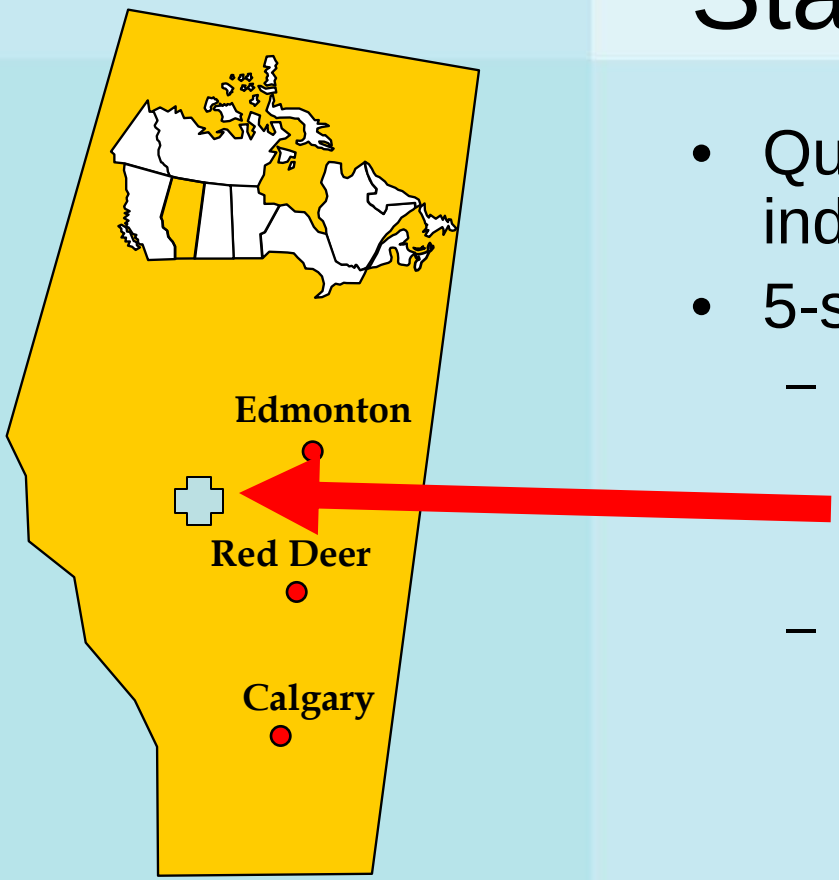
Phase V Current Status



- Quantify costs of CO_2-enrichment of industrial CO_2 waste streams
- 5-spot CO_2-ECBM pilot in Alberta
  - Working with operator with established production
    - Suncor CO_2 Storage and Enhanced Methane Production (CSEMP) project
  - Selection of 2 other multi-well pilot sites

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Goals

Pilot Phases:

- Pilot and operational monitoring
- Verification monitoring
- Environmental monitoring

- Determine baseline production of CBM from coals at the pilot location
- Store CO_2 within coal strata and measure storage effects in the coal
- Determine the effect of CO_2 injection and storage on CBM production
- Assess economic of the collection of CO_2 and injection into coals as a long-term storage method for GHG emission reduction
- Monitor and trace the path of CO_2 movement by geochemical and geophysical methods

Canada ECBM Projects in Alberta

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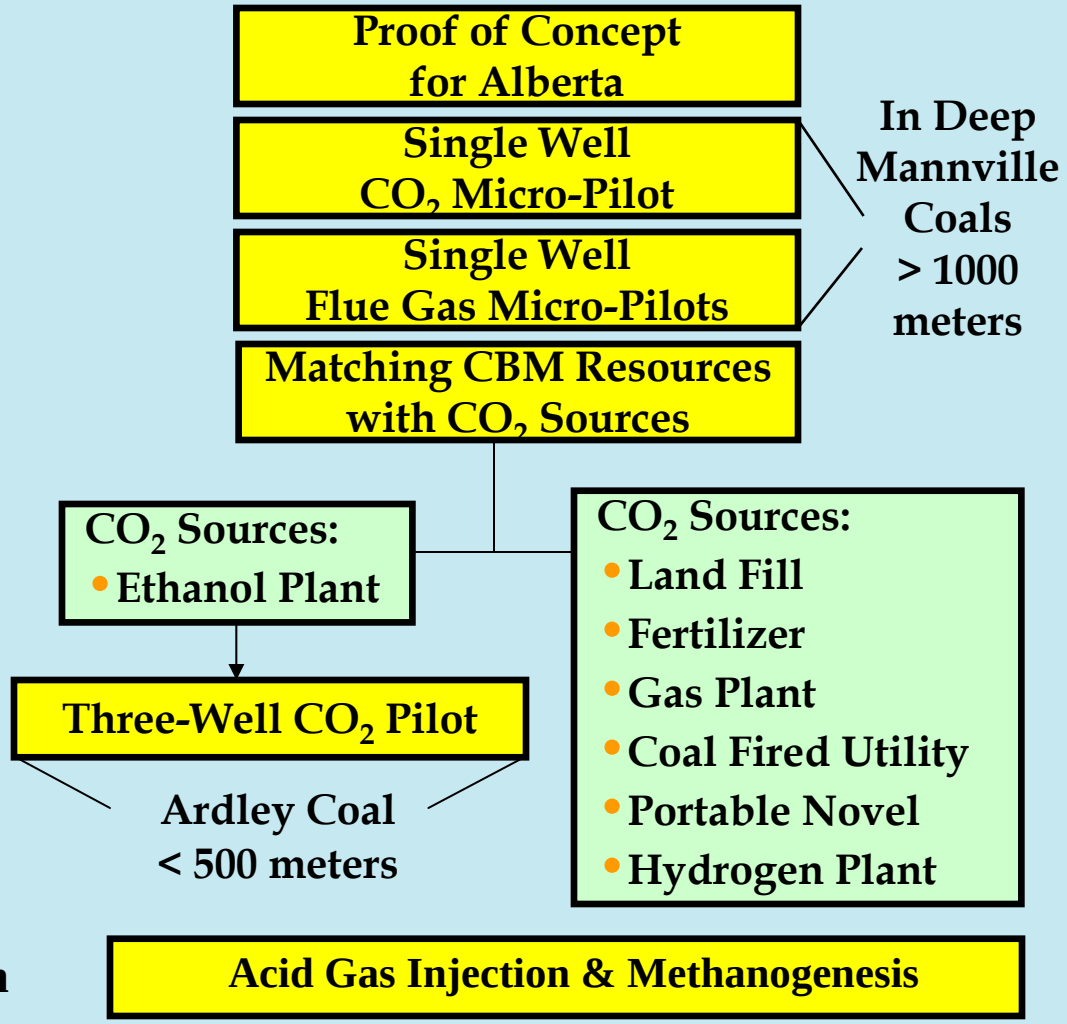
PHASES	YEAR
I	1997
II	1998
IIIA	1999 - 2001
IV	2002 - 2005
V	2002 - 2007
Longer-Term	



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Learnings

- Even in tight reservoirs, continuous CO_2 injection is possible
  - Injectivity declines but can still inject
- Significant enhanced CBM production is predicted
- Injected CO_2 remains in the reservoir while increasing the sweep efficiency