UCG with CCS: A Pathway to a Low-Cost, Low-Carbon Gas for Power Generation and Chemical Syntheses

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Ergo Exergy Technologies Inc.

S. Julio Friedmann

Lawrence Livermore Natl. Lab

NETL CO_2 Conference, May 8-11, 2006

- The Essence…

εUCG™ for:

- IGCC Power Generation
- Synthesis of Clean Fuels & Chemicals
- Replacing coal and NG in Power Plants
- Replacing NG as Chemical Feedstock
- Hydrogen Production

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εUCG Technology:

-Energy, Exergy and UCG

El sueno de la razon produce monstruos

Francisco de Goya

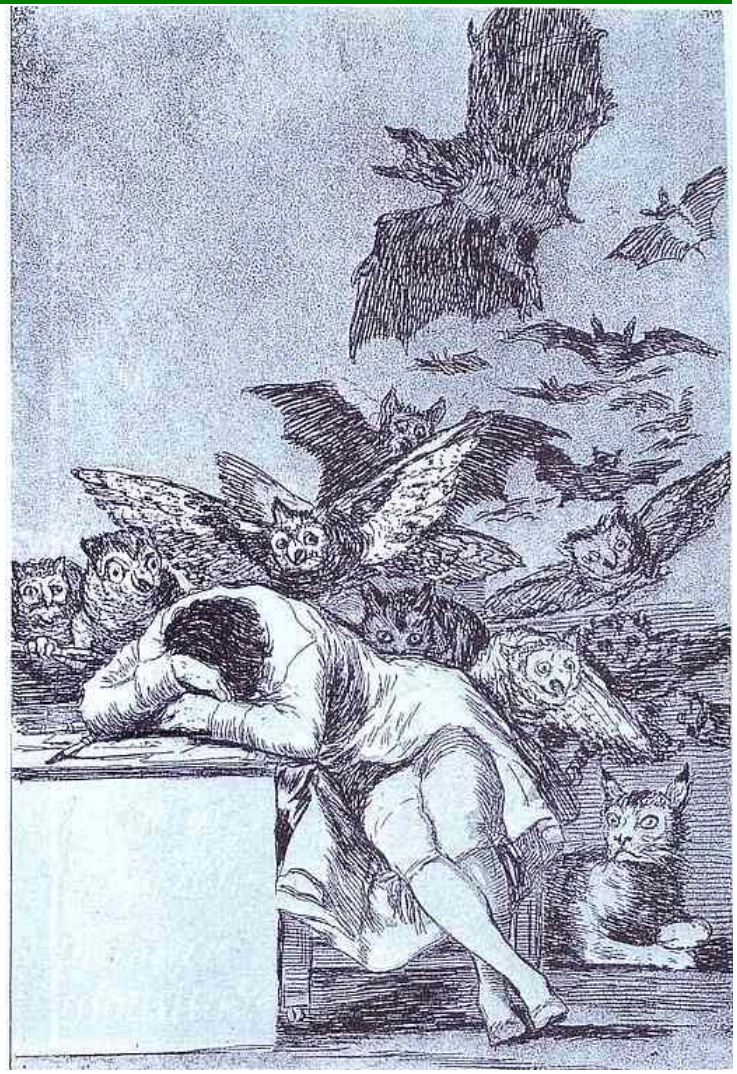
Causes eternal underground fires…

Kills the Environment…

Must be applied deeper than 600 m…

Not cheaper than NG…

Uncontrollable…



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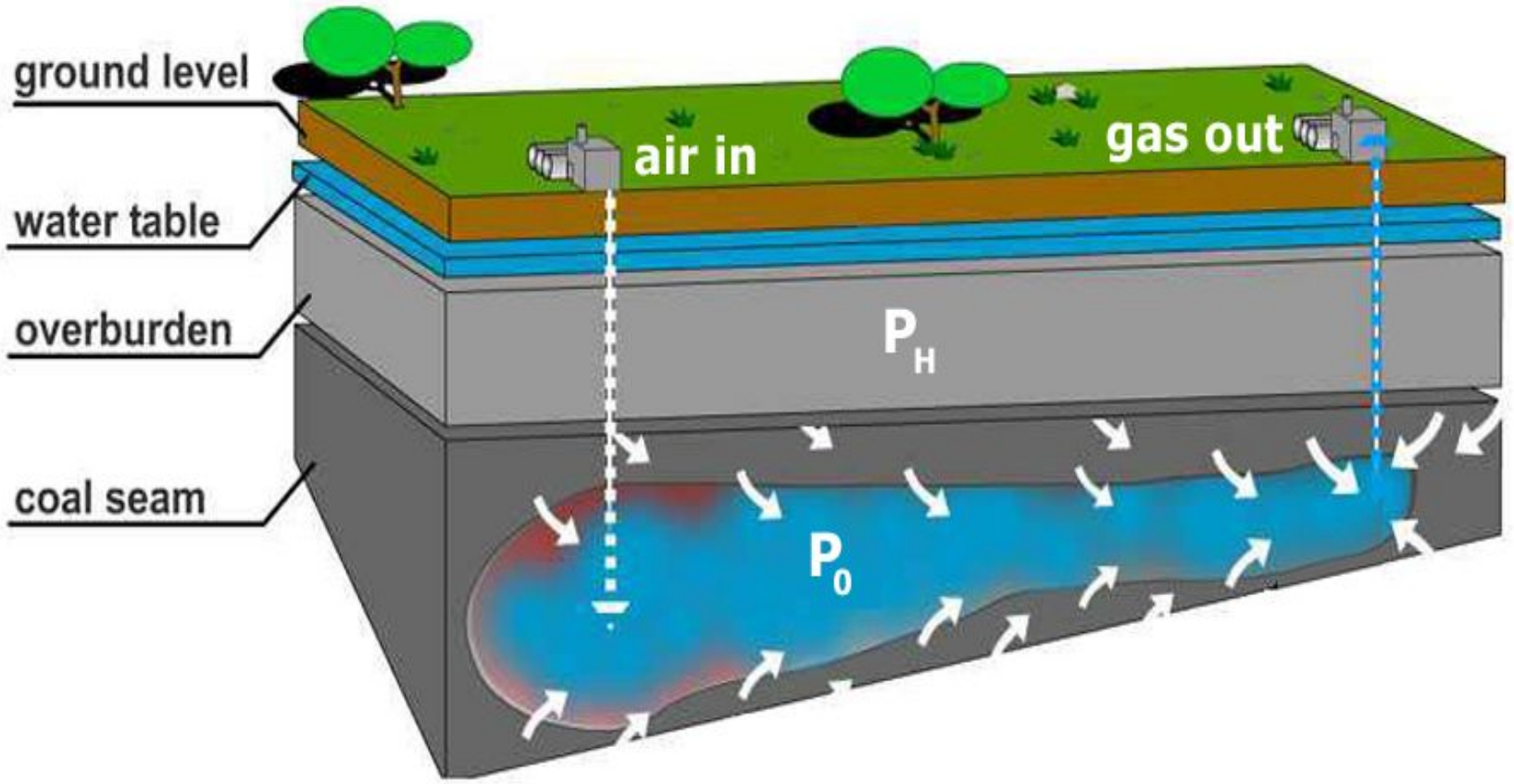
εUCG Technology:

-Energy, Exergy and UCG



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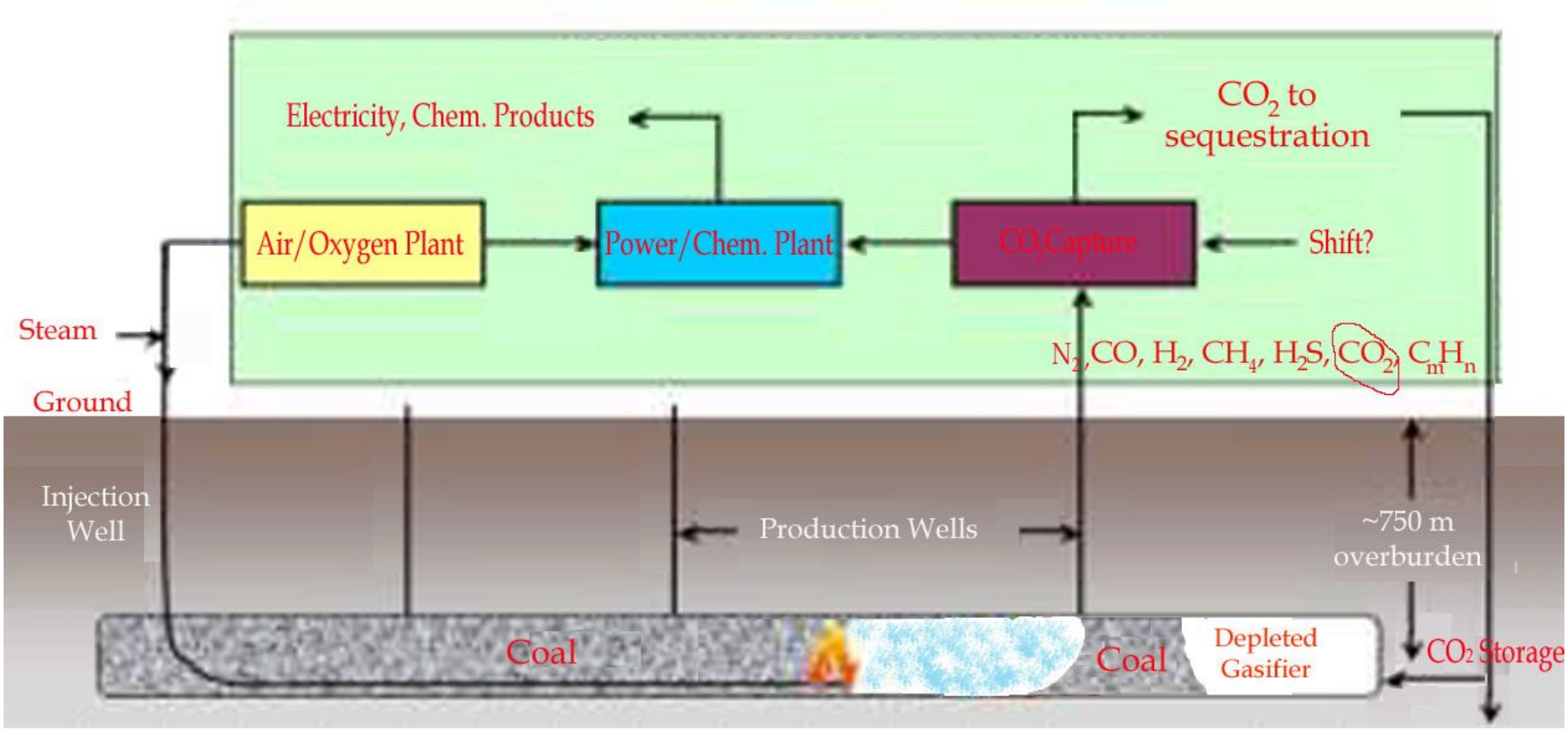
εUCG & Global Warming:
- CO_2- Sequestration



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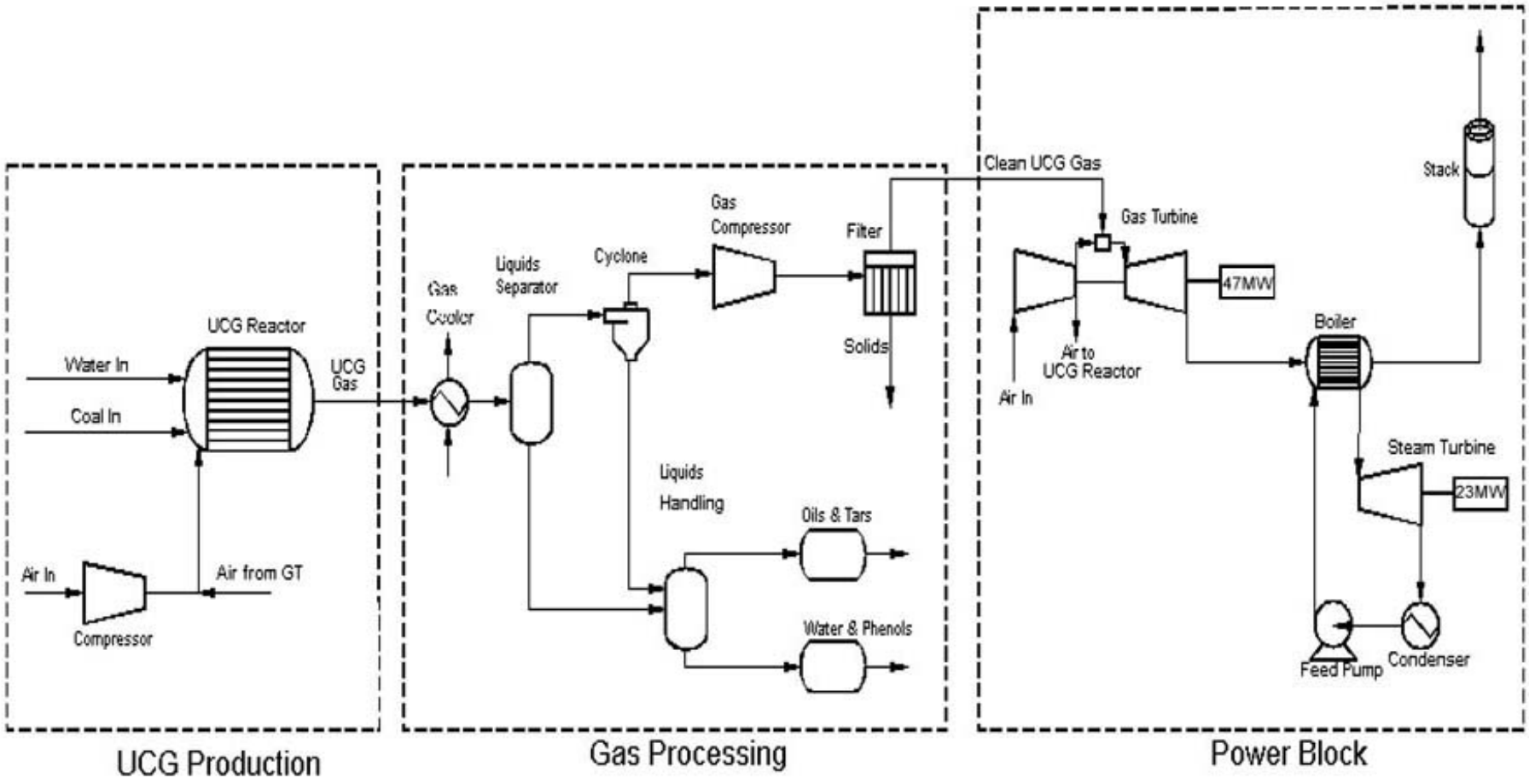
εUCG-IGCC Power Generation
- Process Diagram



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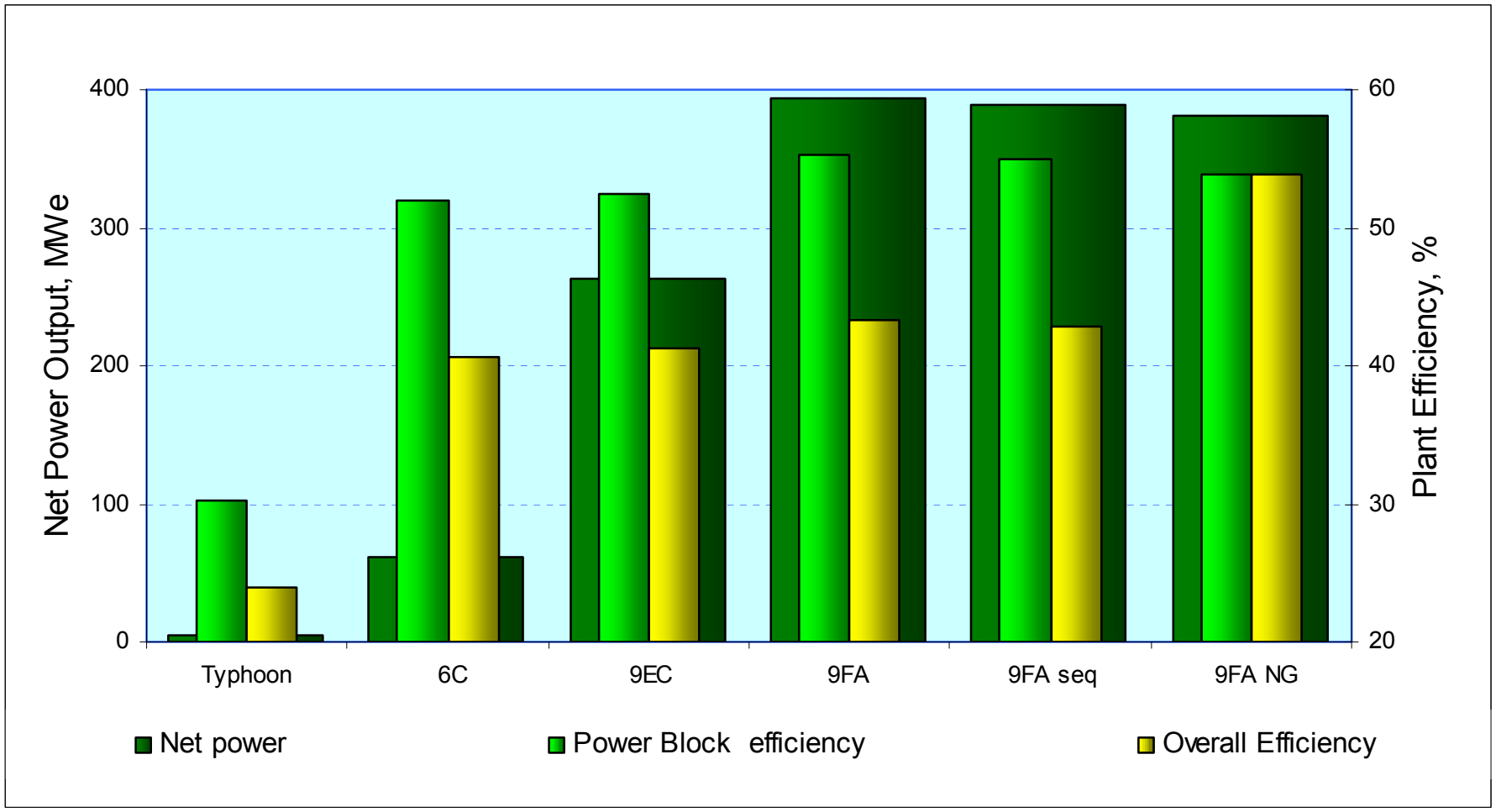
εUCG Power Generation

- Output and Efficiency



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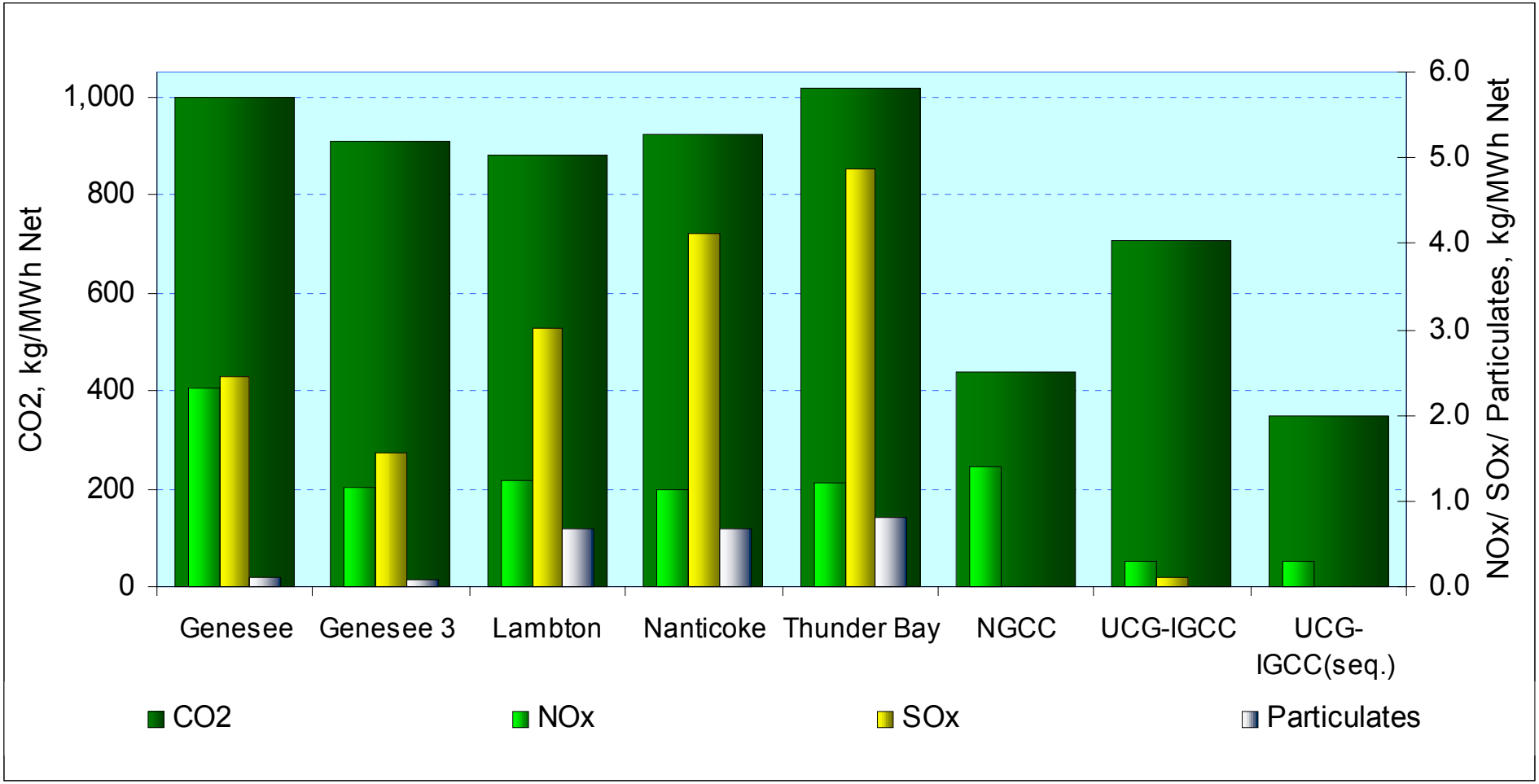
εUCG Power Generation

- Comparing Air Emissions



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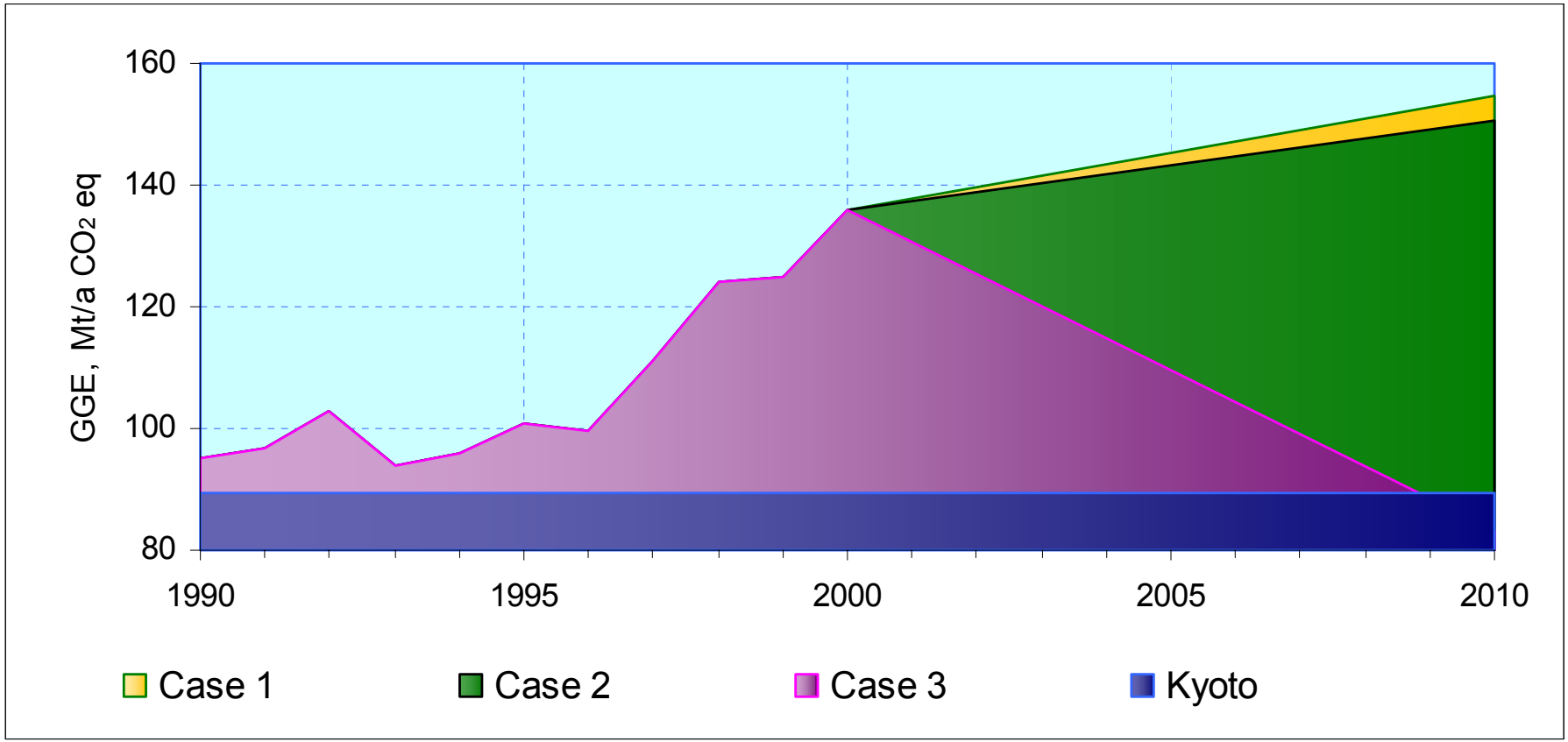
εUCG & Canada Energy Future:
- GGE from Power Generation & Kyoto Targets



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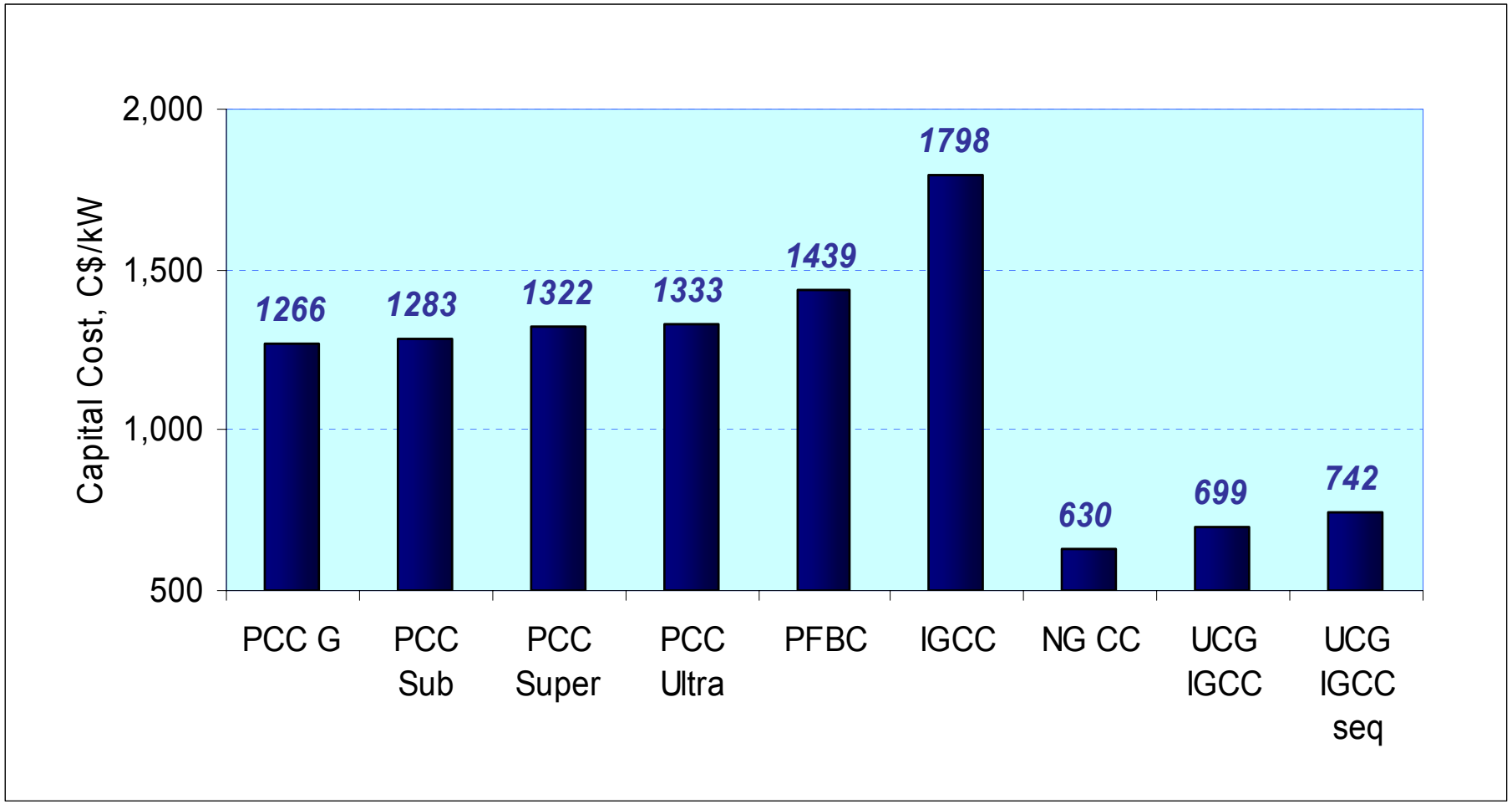
εUCG Power Generation

- Capex of New Power plants, Canada



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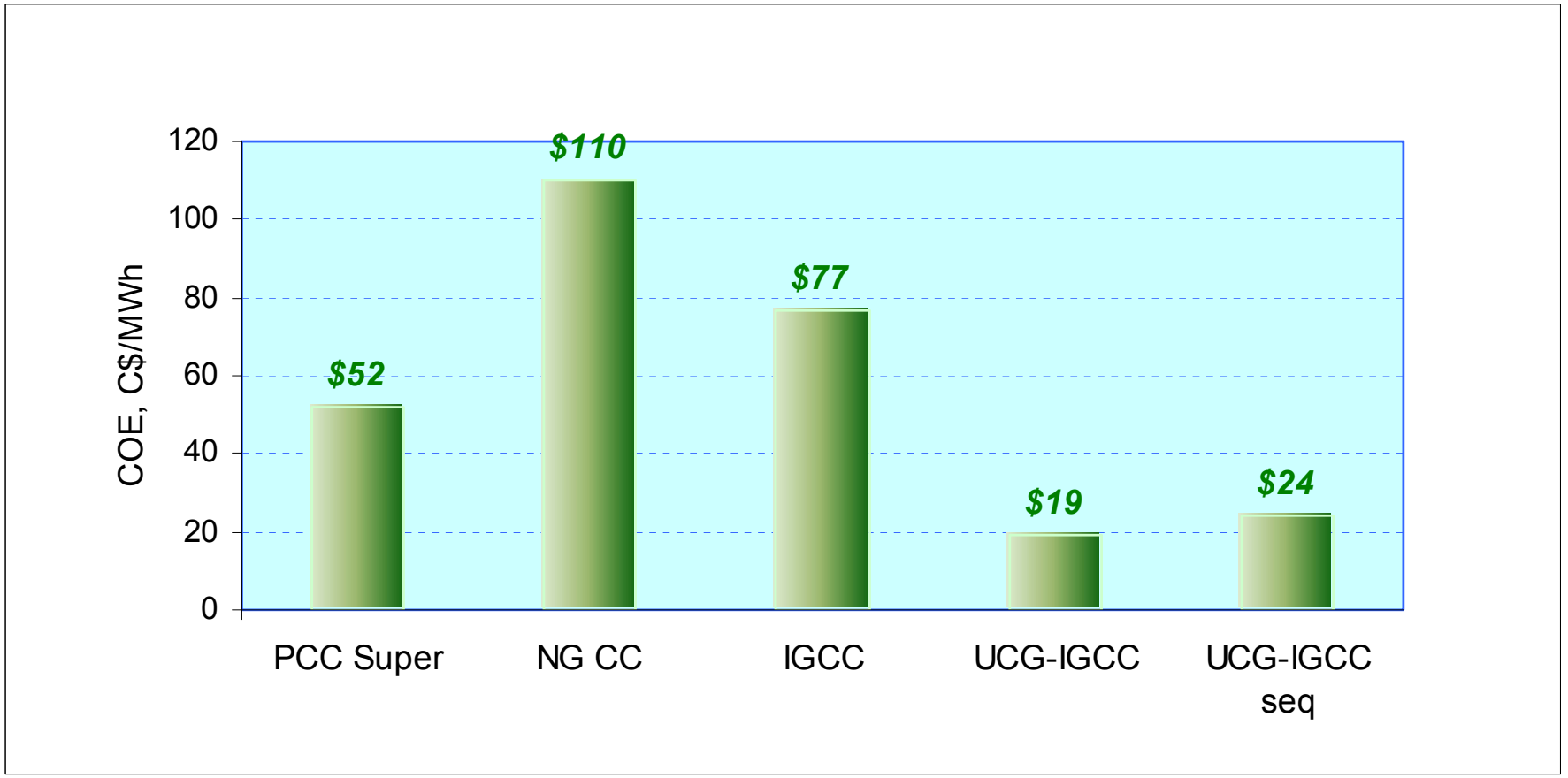
εUCG Power Generation

- Cost of Electricity



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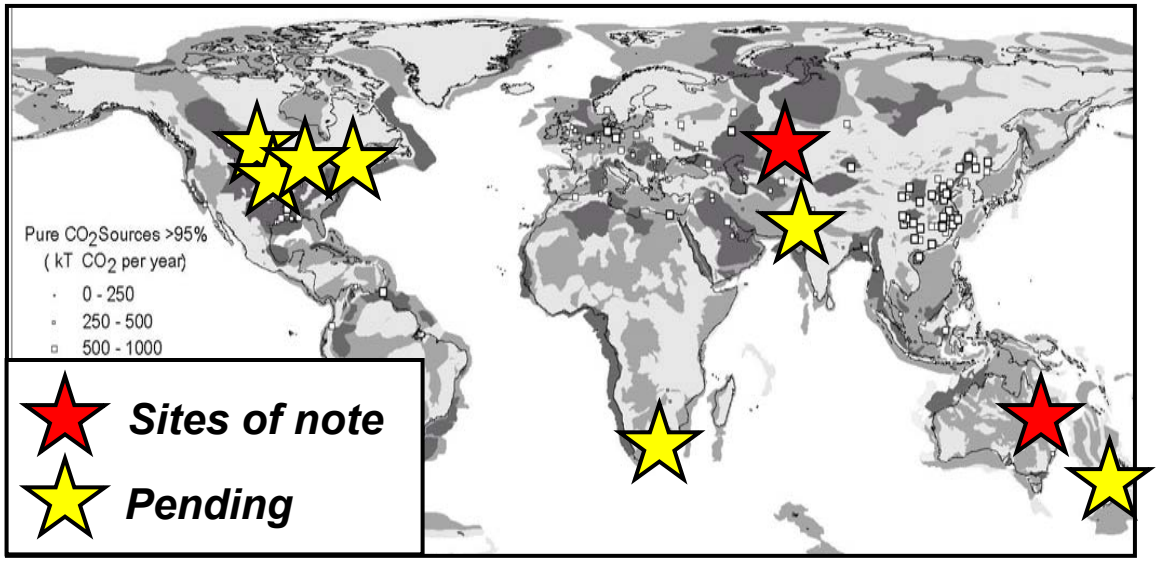
εUCG reduces the cost of CO_2 management!

The high pressure of εUCG syngas can serve to reduce the cost of carbon capture and separation substantially

- Good coincidence between εUCG and CCS sites
- Liquid, natural gas, and H_2 applications require CO_2 separation
- εUCG geological characterization can serve CCS site planning



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εUCG Technology:

- Getting there…

No.	Title	Location	Gas Use	Size	Developer/Licensee	Done to Date	Status
1	Majuba	South Africa	Power Generation, Steam Boiler & Turbine	1,200 Mwe	Eskom Holdings Limited	Site Selection and Pre-Feasibility, Site Characterization, Pilot Plant Design & Construction	Pilot Plant Commissioning
2	Chinchilla	Australia	IGCC+GTL plant: 1. Open Cycle GT 40 MWe 2. CC GT 67 MWe 3. 5 bblpd GTL plant 4. 24,000 bblpd GTL plant	4.4 - 84.0 PJ/a	Linc Energy Ltd	Site Selection and Pre-Feasibility, Site Characterization, Pilot Plant Design & Construction, Commissioning & Operation, Controlled Shutdown, Post-Gasification operations & Monitoring, Gas Cleanup Demonstration, Detailed Design of IGCC plant, Complete tender for Major Equipment	Expansion of Gas Production, Preparation for Installation of Gas Turbine, preparation for IPO
3	Barmer	India	IGCC Plant	750 MWe	Gas Authority of India Ltd	Site Selection, Initial UCG Study, Costing of Pilot and Demonstration Plant (UCG+IGCC)	Pre-Feasibility Study
4		Australia	Power Generation, Steam Boiler & Turbine	230 MWe		Site Selection	Fundraising
5	NZUCG	New Zealand	Multiple	360 MWe	Solid Energy NZ	Selection of NZ coalfields for UCG, Screening Study	Pre-Feasibility
6	LingUCG	Canada	Power Generation, Steam Boiler & Turbine	300 MWe	Laurus Energy Inc.	Selection of Canada coalfields for UCG, Scoping Study, Permitting	Fundraising
7	CB GS	Canada	Re-powering NG CC plant	660 MWe	Laurus Energy Inc.	Site Selection, Scoping Study	Takeover of Power Plant
8	Bhakkar	Pakistan	town gas	1.3 PJ/a	DDFC Group	Preliminary Study	Pre-Feasibility Tender
9	PRB UCG	USA	GTL, SNG	>30 PJ/a	Gastech Inc.	Holdings of 14 billion ton of coal	Scoping Study
10	ND UCG	USA	SNG, CO2 sequestration	> 40 PJ	Private Developer	Site Selection, Preliminary Costing	Project Structuring
11	Thar IGCC	Pakistan	IGCC	1,700 MWe	EML, Pict Energy	Site Selection & Screening Study	Fundraising
12	NLC PP	India	Power Generation	400 Mwe	Neyveli Lignite	Scoping Study	Formal Tender for Pilot Plant
13	Vesme	Italy	IGCC plant	450 MWe	Carbosulcis SPA	Site Selection Initial Study	Initial Study

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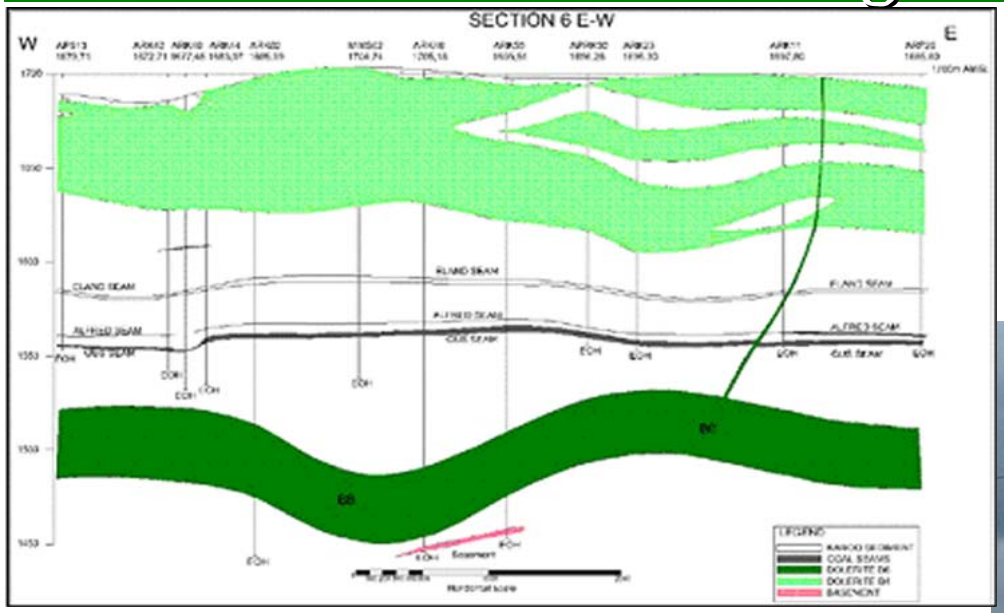
Majuba εUCG Project:

- Co-Firing (South Africa)



Majuba Power Plant:

4,200 MWe

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Eskom

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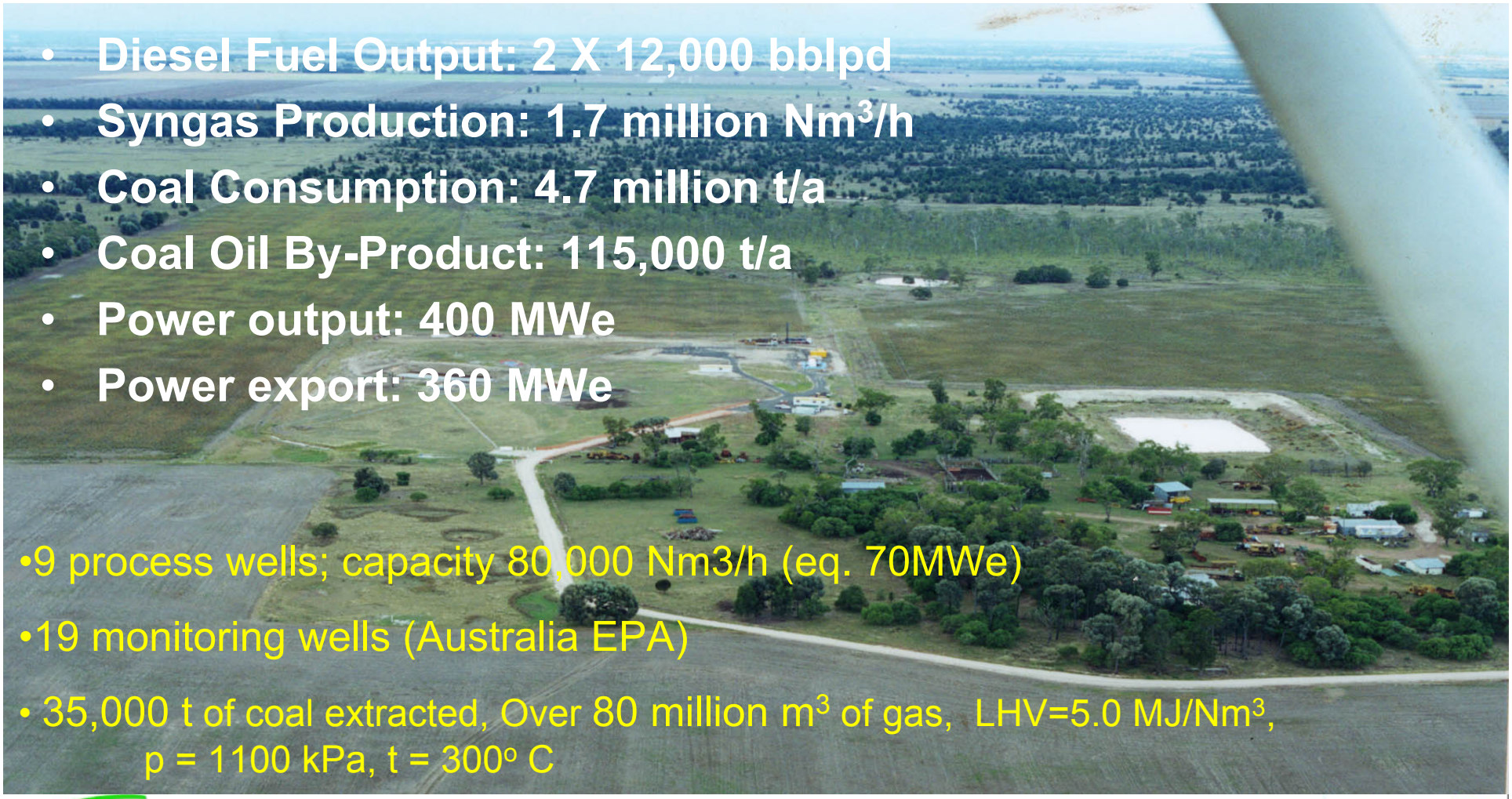
The Chinchilla Project

- The Largest and the Longest in the West…



- **Diesel Fuel Output: 2 X 12,000 bblpd**
- **Syngas Production: 1.7 million Nm^3/h**
- **Coal Consumption: 4.7 million t/a**
- **Coal Oil By-Product: 115,000 t/a**
- **Power output: 400 MWe**
- **Power export: 360 MWe**

•9 process wells; capacity 80,000 Nm3/h (eq. 70MWe)

•19 monitoring wells (Australia EPA)

• 35,000 t of coal extracted, Over 80 million m^3 of gas, LHV=5.0 MJ/Nm^3, p = 1100 kPa, t = 300^o C

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LINC energy Ltd

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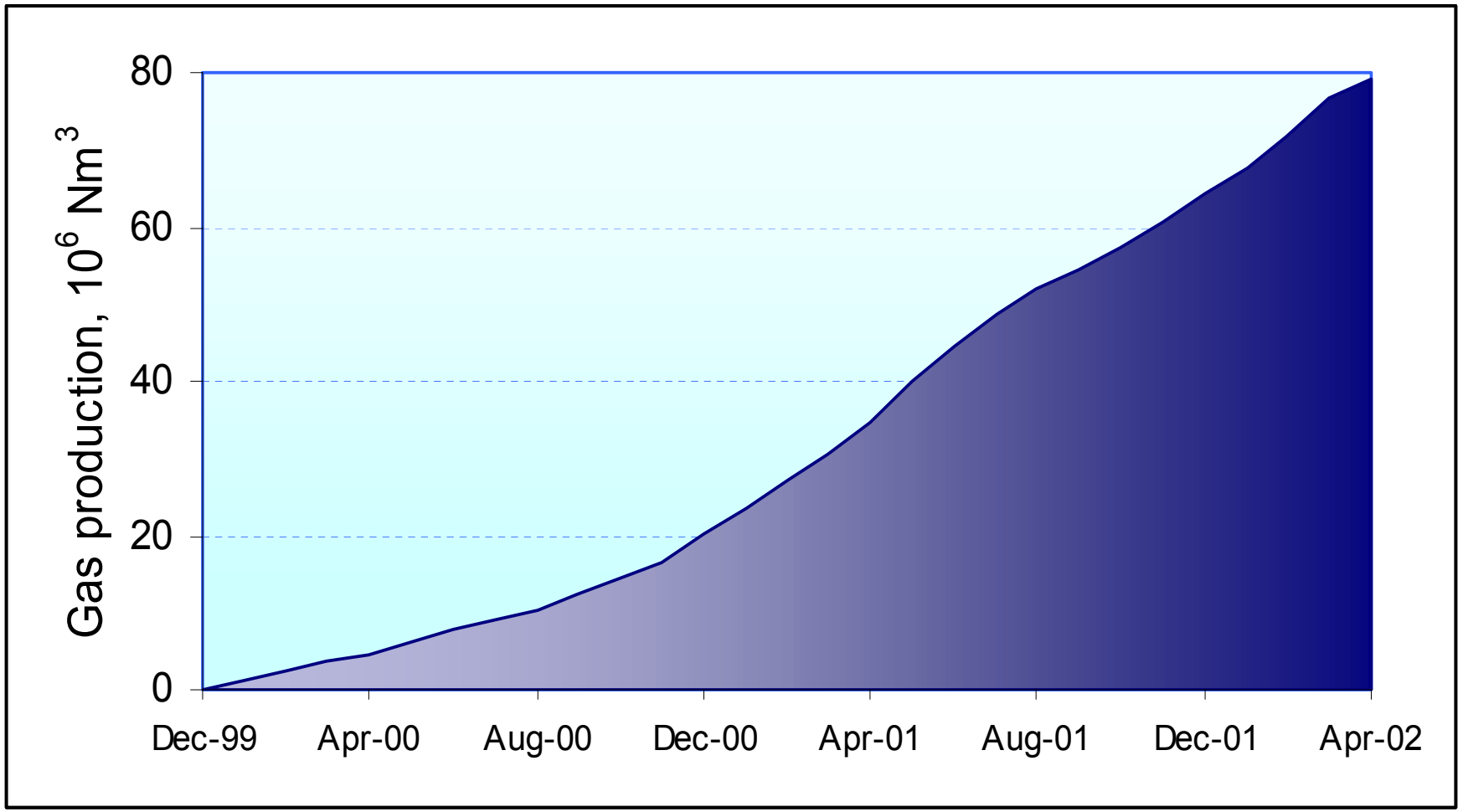
The Chinchilla Project
- Gas Production –100% Availability



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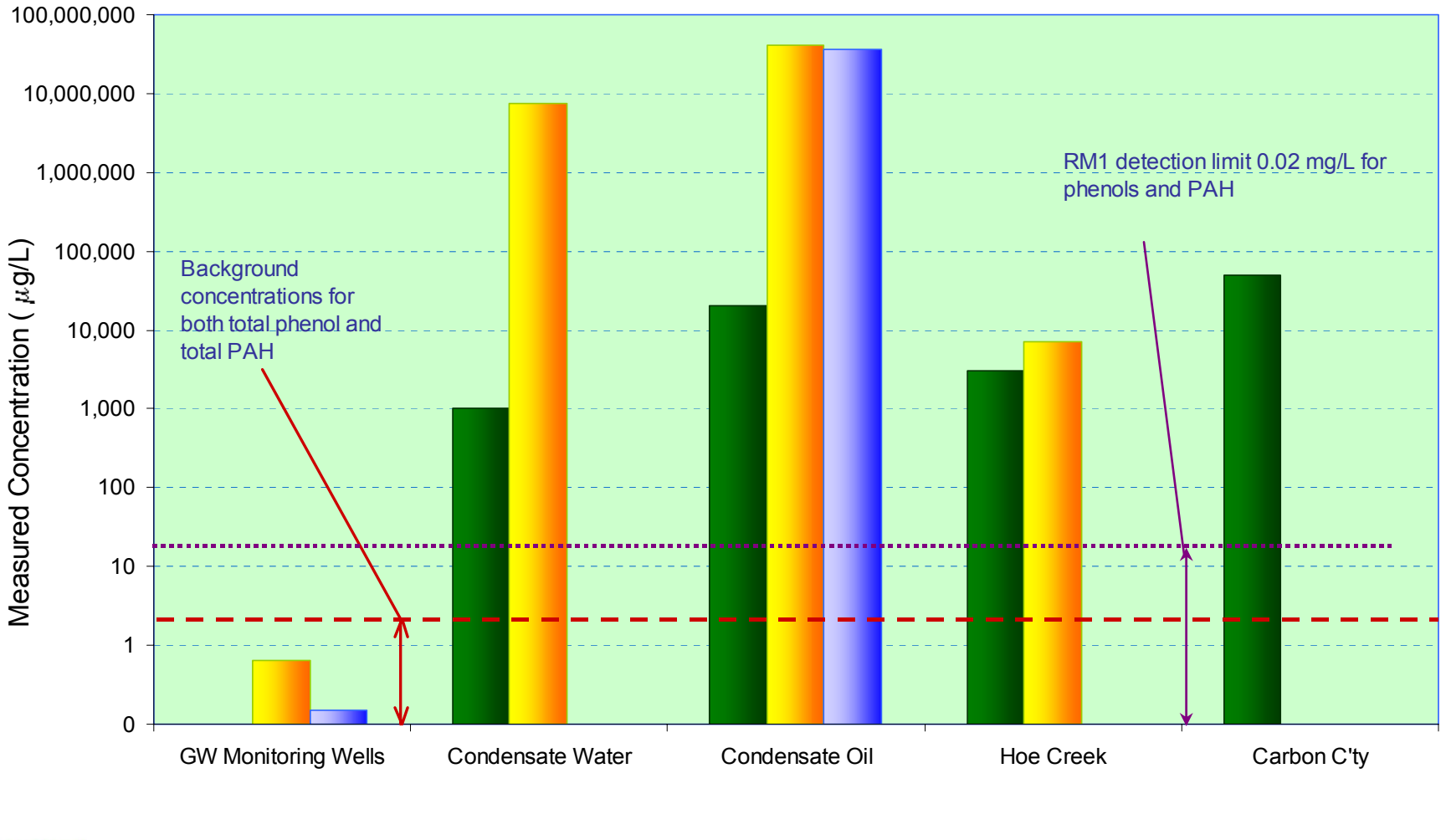
The Chinchilla Project
- Groundwater Monitoring



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The Chinchilla Project

- Current Status

Maintained in Preparation for Resuming Gas Production

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SNG from εUCG :
- ND SNG Project

Process Streams	Quantity, t/day	Flow Rate, Nm^3/day	Pressure, barg	LHV, MJ/Nm^3	Cost, $/GJ
Coal	5,046				
O2	1,085	759,500	12.00		
Steam	4,759	5,922,100	12.00		
O2 Syngas, wet	50,793	57,942,800	10.50	10.14	***1.20***
O2 Syngas, dry	31,439	33,700,800			
SNG	1,164	1,712,329	70.00	32.00	***2.50***
By-Products:					**Value, $/t**
Phenols	28				1800
Hydrocarbons	347				200
NH3	48				700
CO2	40,974				?
Liquid N2	3,571				?
Naphtha	46				450

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Project Developer

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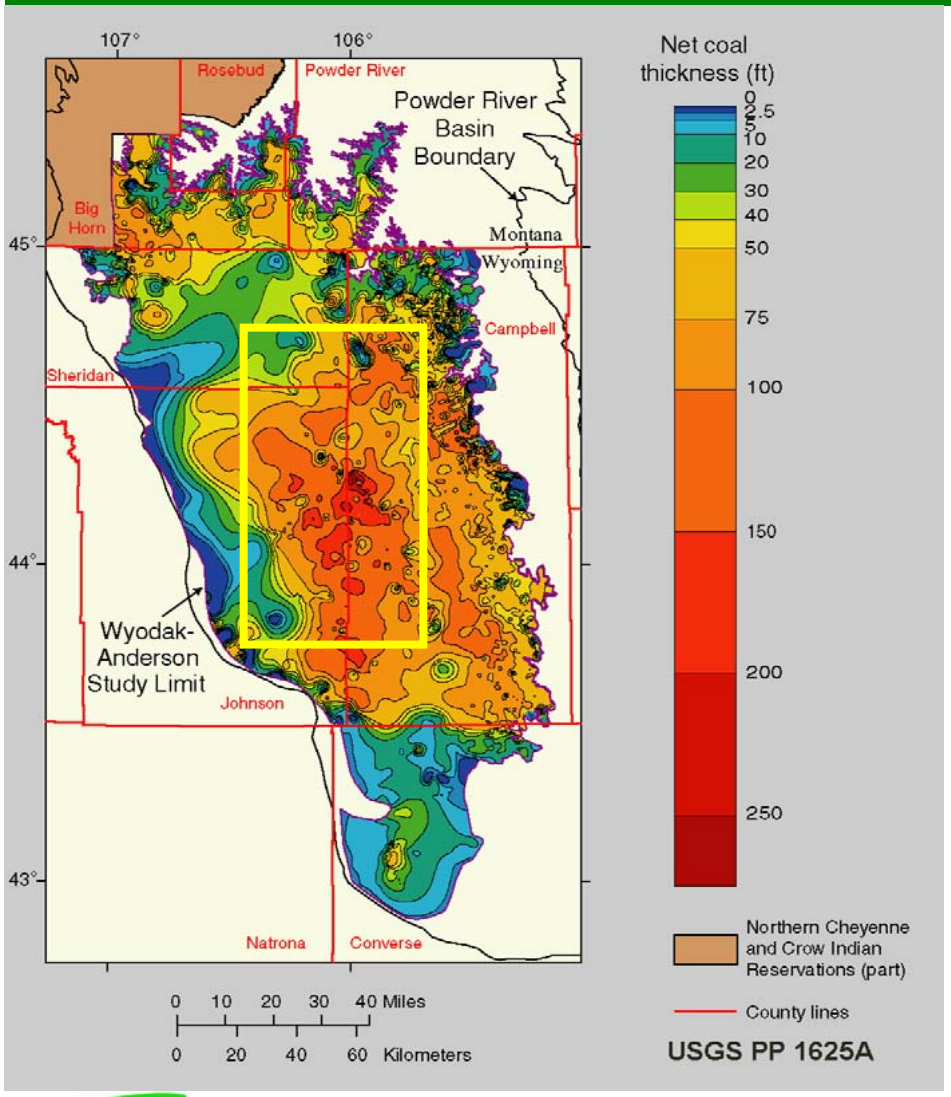
Coal-to-Liquid via εUCG :
- PRB εUCG Project



- **80,000 acres** of State of Wyoming coal leases
- **13 + billion tons of coal** on GasTech leases
- Two Sections (square mile each) in every 36 sq mi Township → broad coverage

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GasTech, Inc.
Casper, WY, USA

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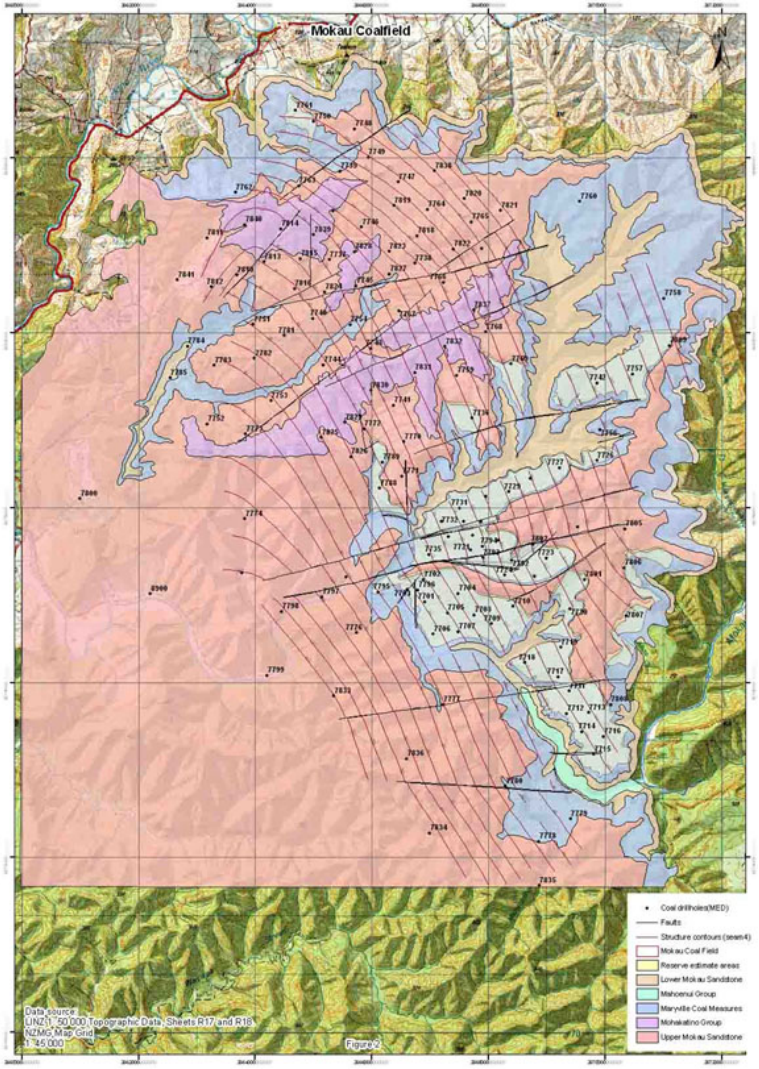
NZ εUCG Project:

- Site Selection & Scoping Complete…

14 billion t of coal and lignite analyzed to select 5 primary fields and to scope the first **ε**UCG project

First **ε**UCG +CCS project



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SOLID ENERGY
Coals of New Zealand

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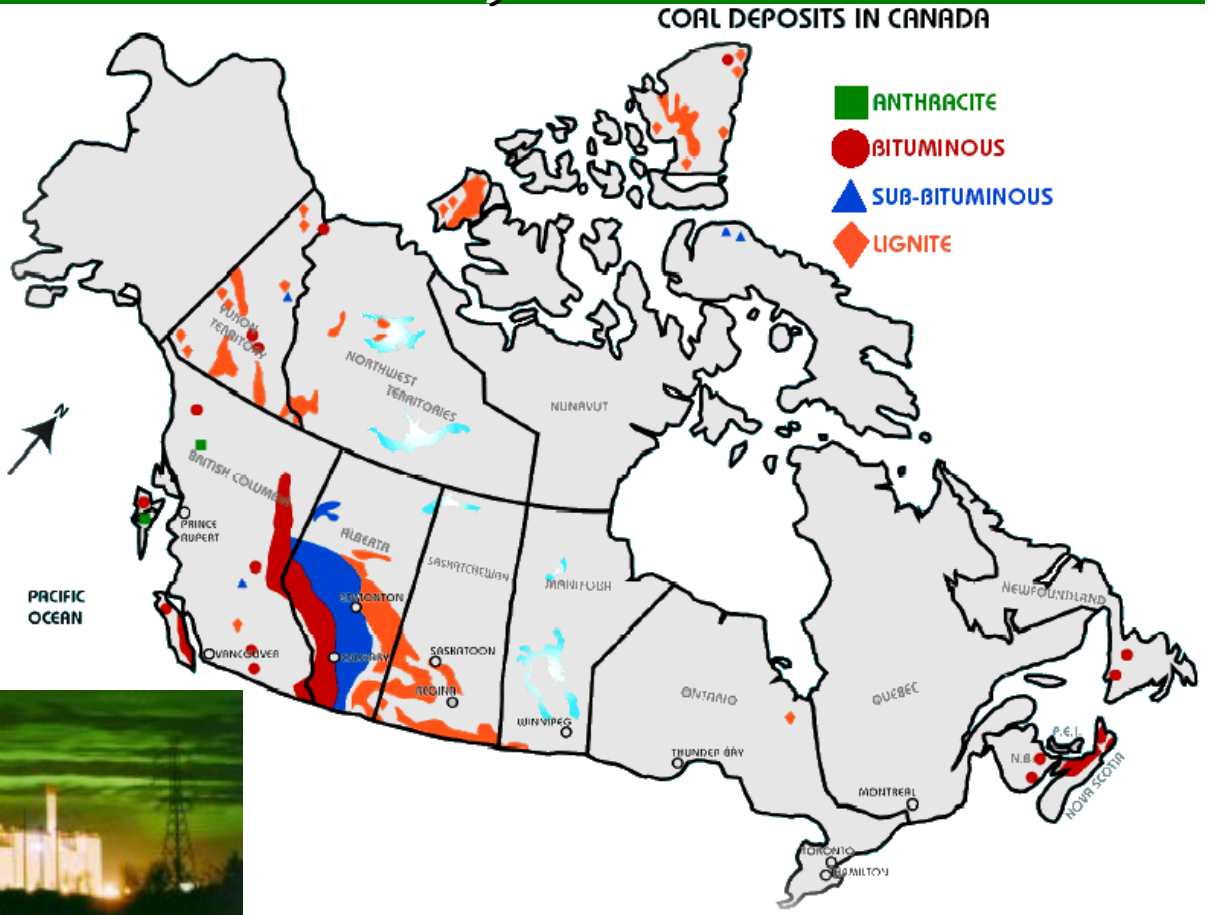
Canadian Potential:

- Coal Reserves suitable for εUCG

AB > 1,000 b ton

BC > 20 b ton

NS > 1 b ton



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Laurus Energy Inc.

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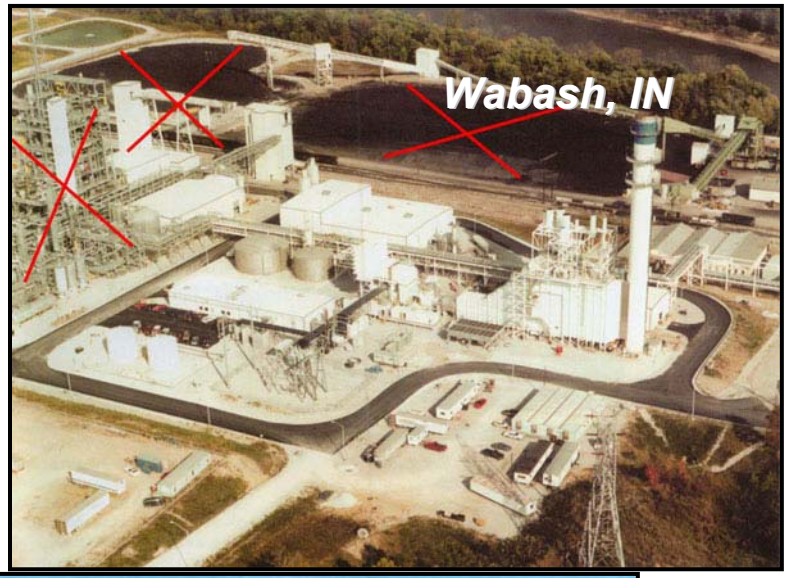
εUCG :
- Low-cost Source of Hydrocarbons

- No mining
- No purchase of coal; no ash management
- No gasifier purchase or operation
- High pressure syngas stream = low-cost CO_2 separation
- No particulates or NO_x; sulfur management straightforward
- Good coincidence between CCS and UCG sites



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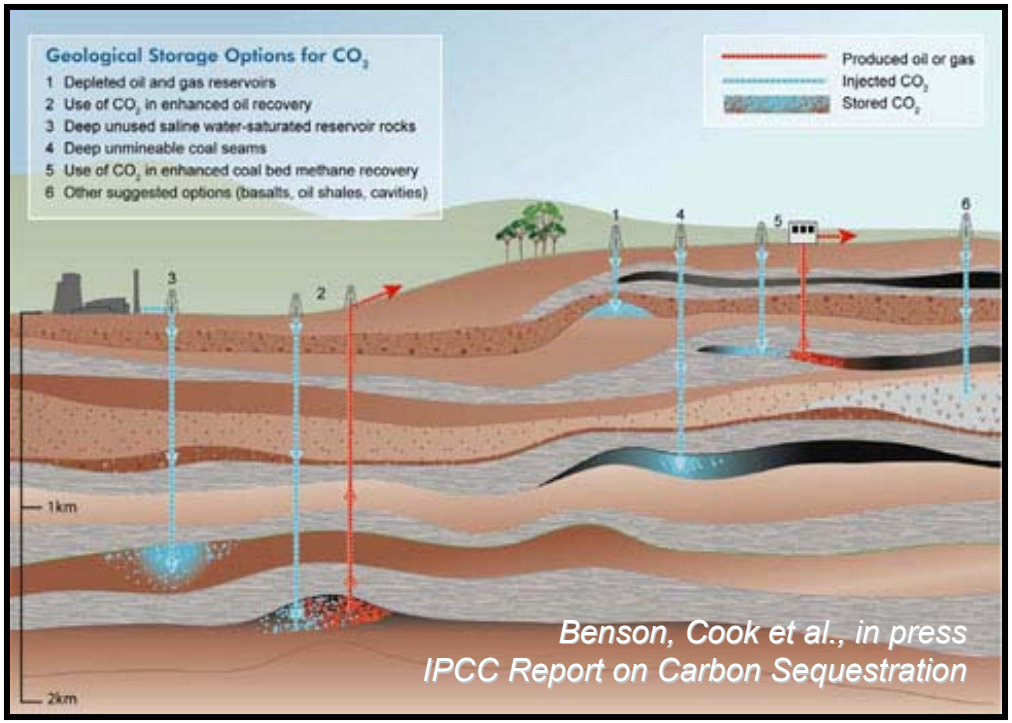
εUCG CO_2 geological storage:
several geological targets, supercritical phase



- Saline Aquifers
- Depleted Oil & Gas fields
  (w/ or w/o EOR and EGR)
- Unmineable Coal Seams
  (w/ or w/o ECBM)

These formations are likely to be found near coal seams chosen for UCG

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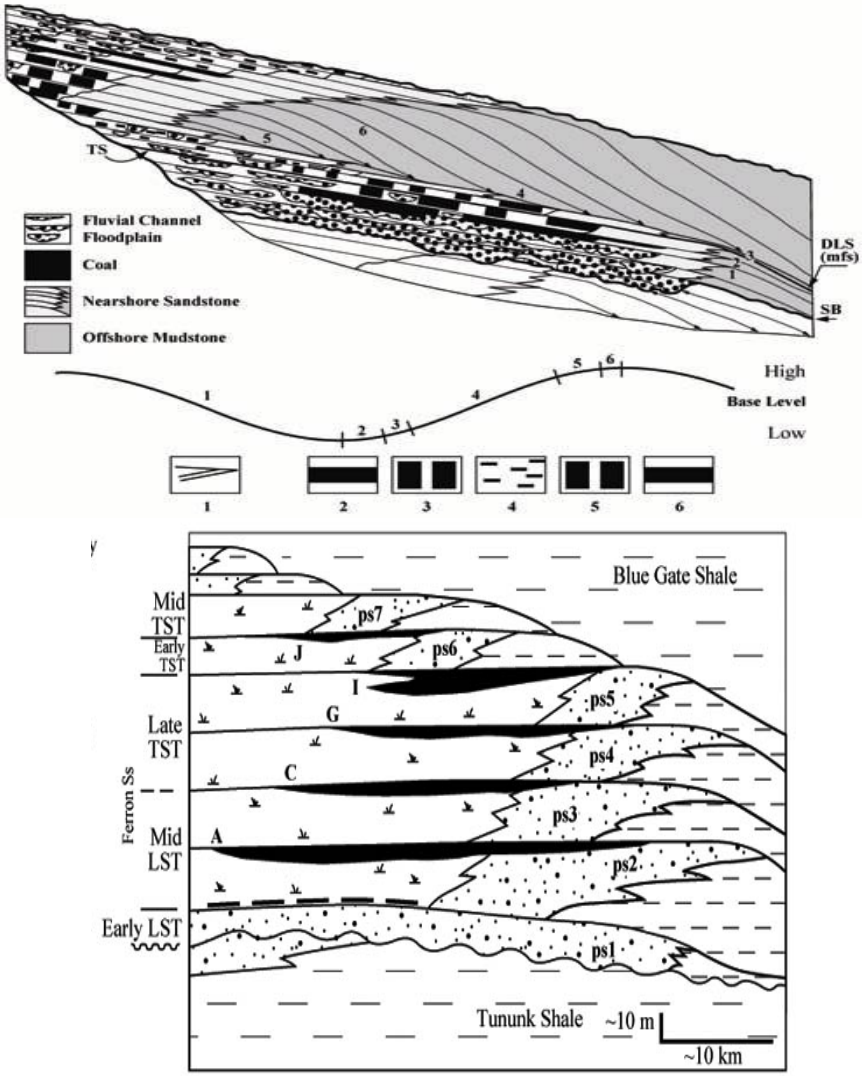
εUCG creates porous, permeable zones within the strata

Potential advantages to storing CO_2 within εUCG zone.

- *Substantial apparent capacity*
- *Highly permeable; high injectivity*
- *Potential secondary coal adsorption storage; autoclosure through swelling*
- *Existing well set; potential for engineering control*
- *Potential to site within highly secure settings (coals beneath shales; seams at supercritical T-P conditions)*

These advantages are unique to the εUCG-CCS system, and worthy of serious investigation



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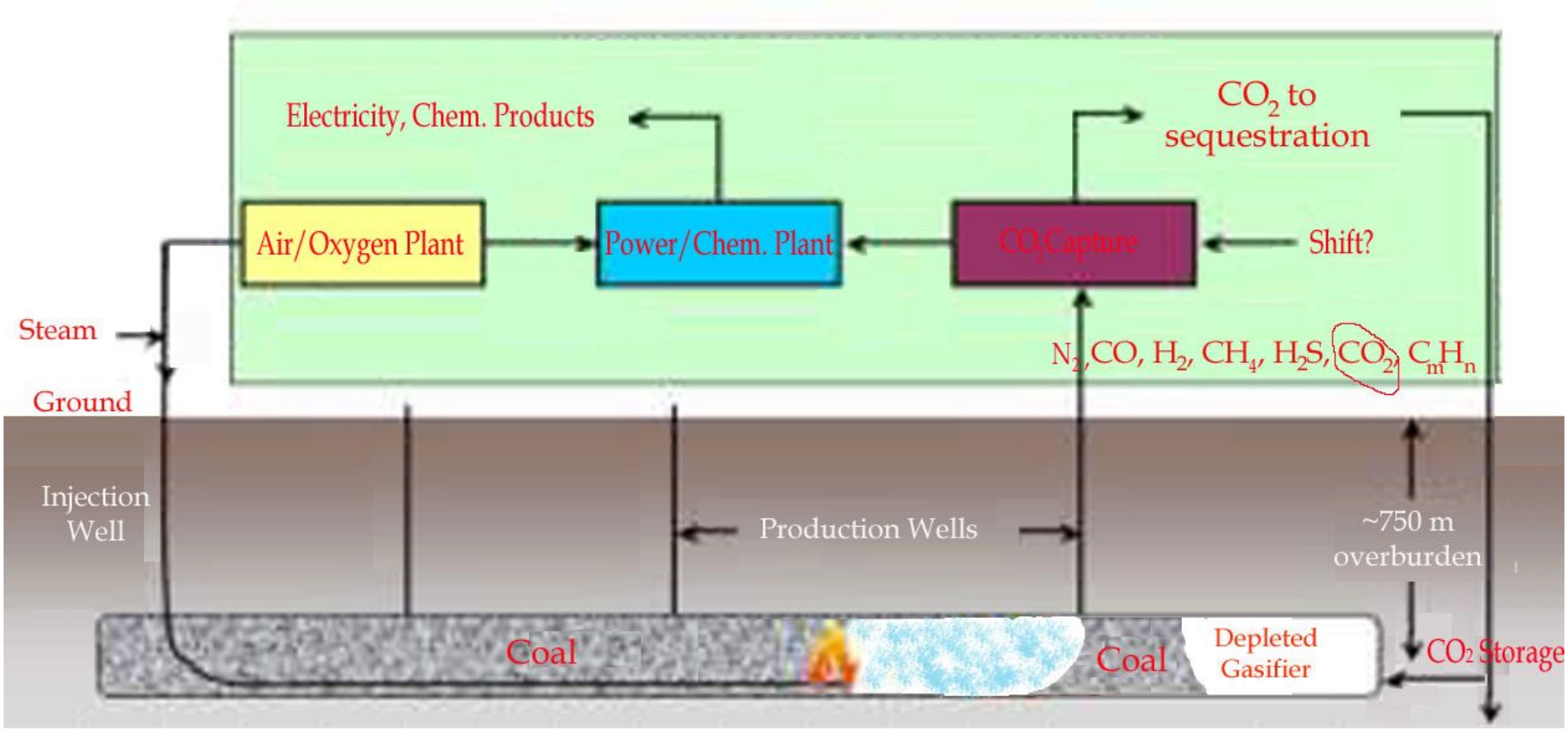
εUCG & Global Warming:
- CO_2- Sequestration



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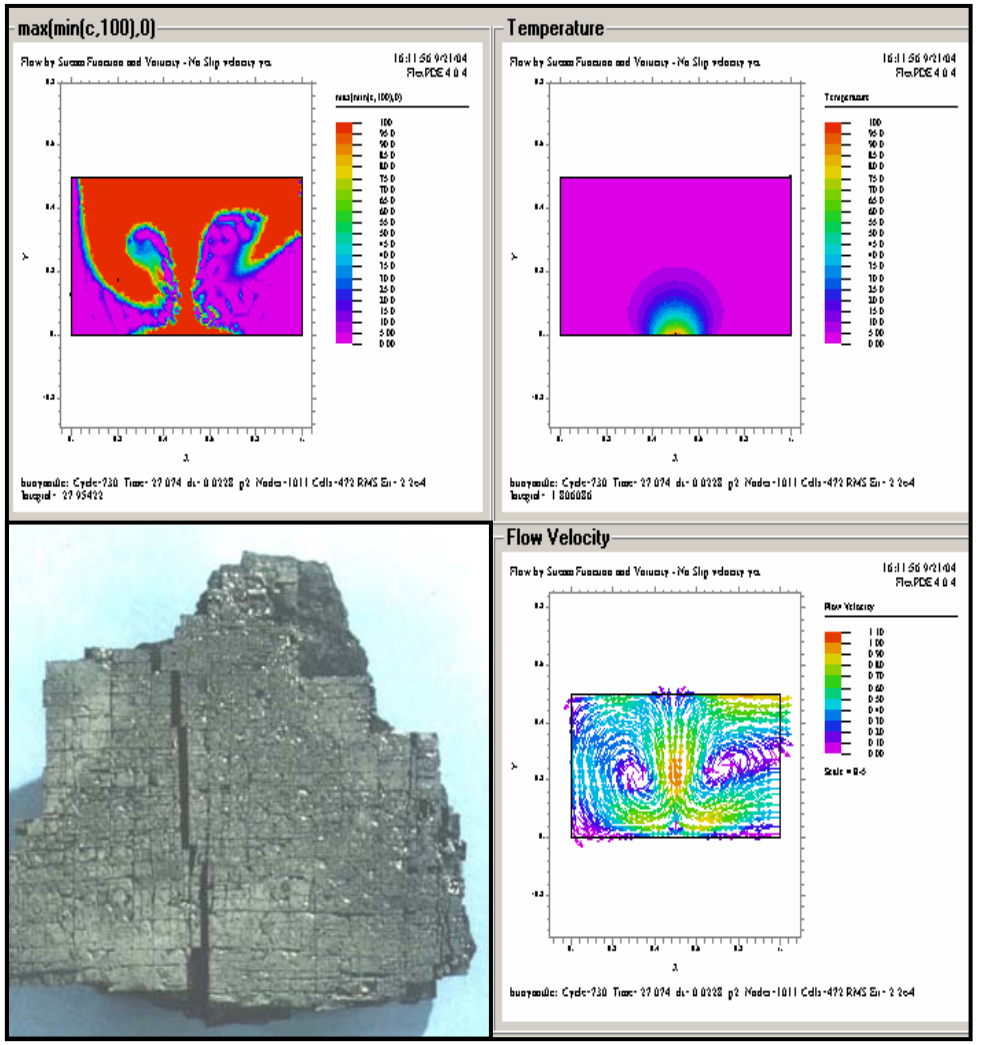
UCG process alters the seam:
thermal, mechanical, and chemical changes

Factors affecting CO_2 storage within UCG zone.

- ***Heating/quenching effects on fractures***
- ***Carbonic acid leaching of ash, tars, char, coal***
- ***Transport of VOCs, metals***
- ***Dynamic nature of post-gasification volume***
- ***Uncertainty in initial environment***

These concerns make it necessary to address key scientific and technical questions in a substantial research program



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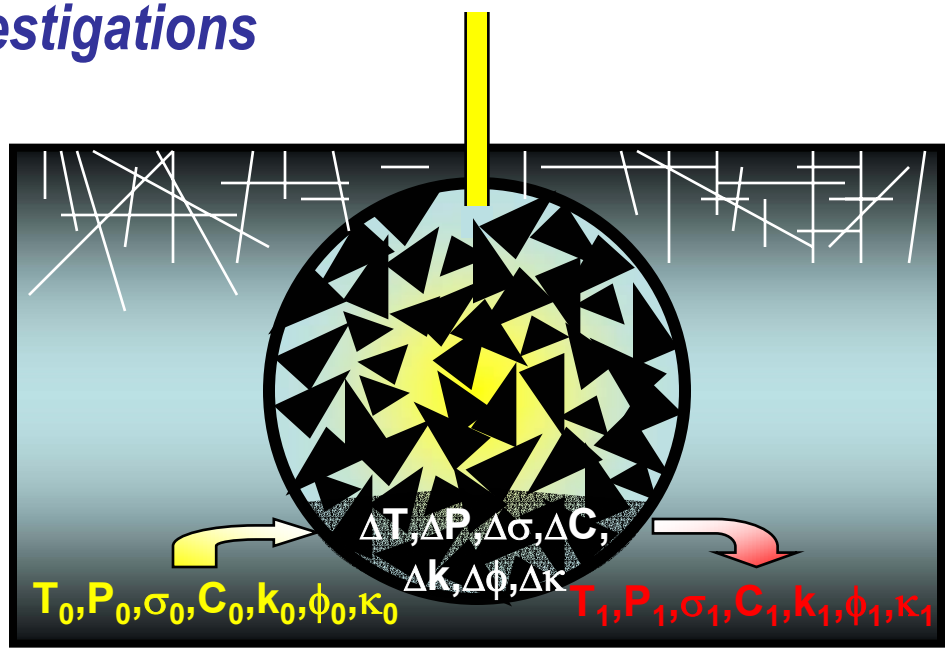
Advantages & Disadvantages:
- targeted research program

Key scientific concerns to be addressed in lab, simulation, and field-based investigations

- **T-P-D constraints for effective storage operation**
- **Geomechanical response**
- **Environmental risk from displaced UCG zone water**
- **Geochemical effects**
- **Long-term fate of CO_2**



These concerns can be addressed quickly and effectively with a research agenda involving experiments, coupled-process simulations, and field injections, monitoring, and verification

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Conclusions:
- εUCG & CCS

- *εUCG is a Low-Cost Technology to Produce Hydrocarbons from Unminable Coal*
- *εUCG -IGCC has high efficiency and Low Emissions of CO_2 and Criteria Pollutants*
- *Energy Penalty and Cost of Capture and Re-Compression of CO_2 in εUCG are very attractive*
- *εUCG locations are co-incident with prospective CCS sites*

- *εUCG creates unique opportunities for Carbon Storage in post-gasification structures:*

Advantages and Potential risks are studied further

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