UCG
What & Where, History & Future

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African Carbon Energy

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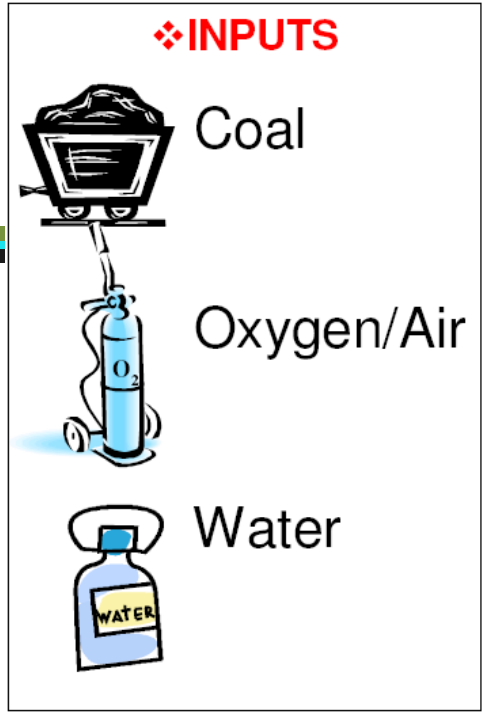
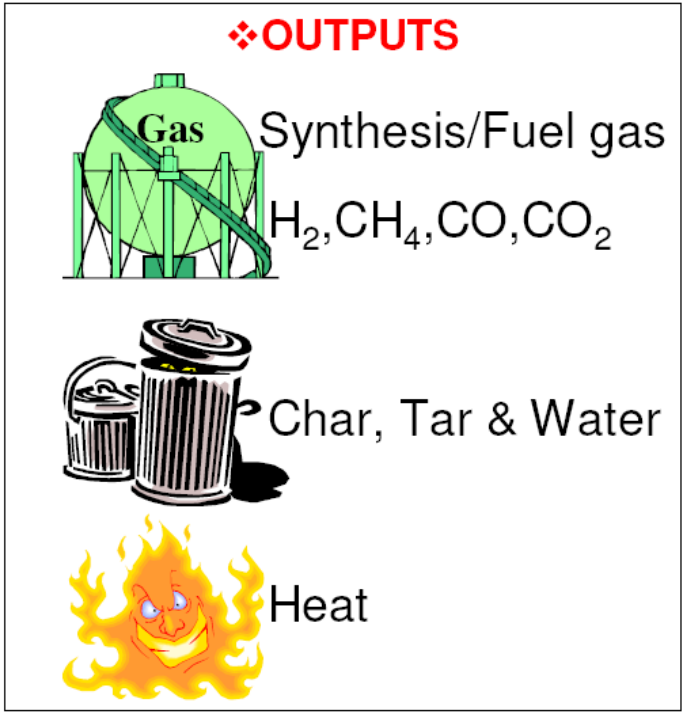
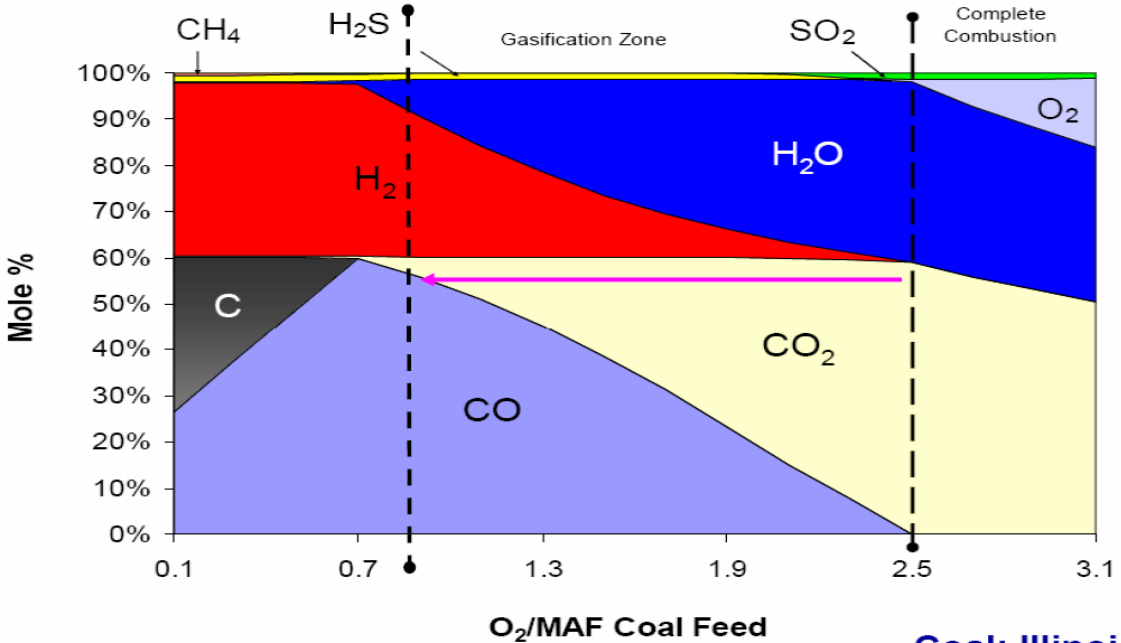
What is Gasification?

Gasification is the partial combustion of Coal with O_2 and water







Underground coal gasification is like other coal gasification techniques (Sasol® FBDB™), except that the geological strata form the reaction vessel and groundwater is used as process chemical.

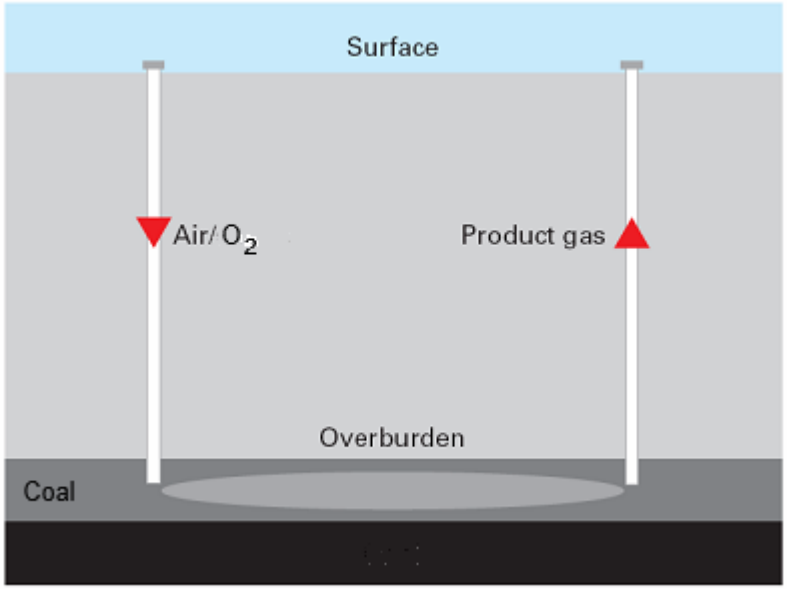
This lowers cost, but adds a level of complexity to analysis of the process behaviour and leads to extra uncertainty due the geological environment.

What is UCG

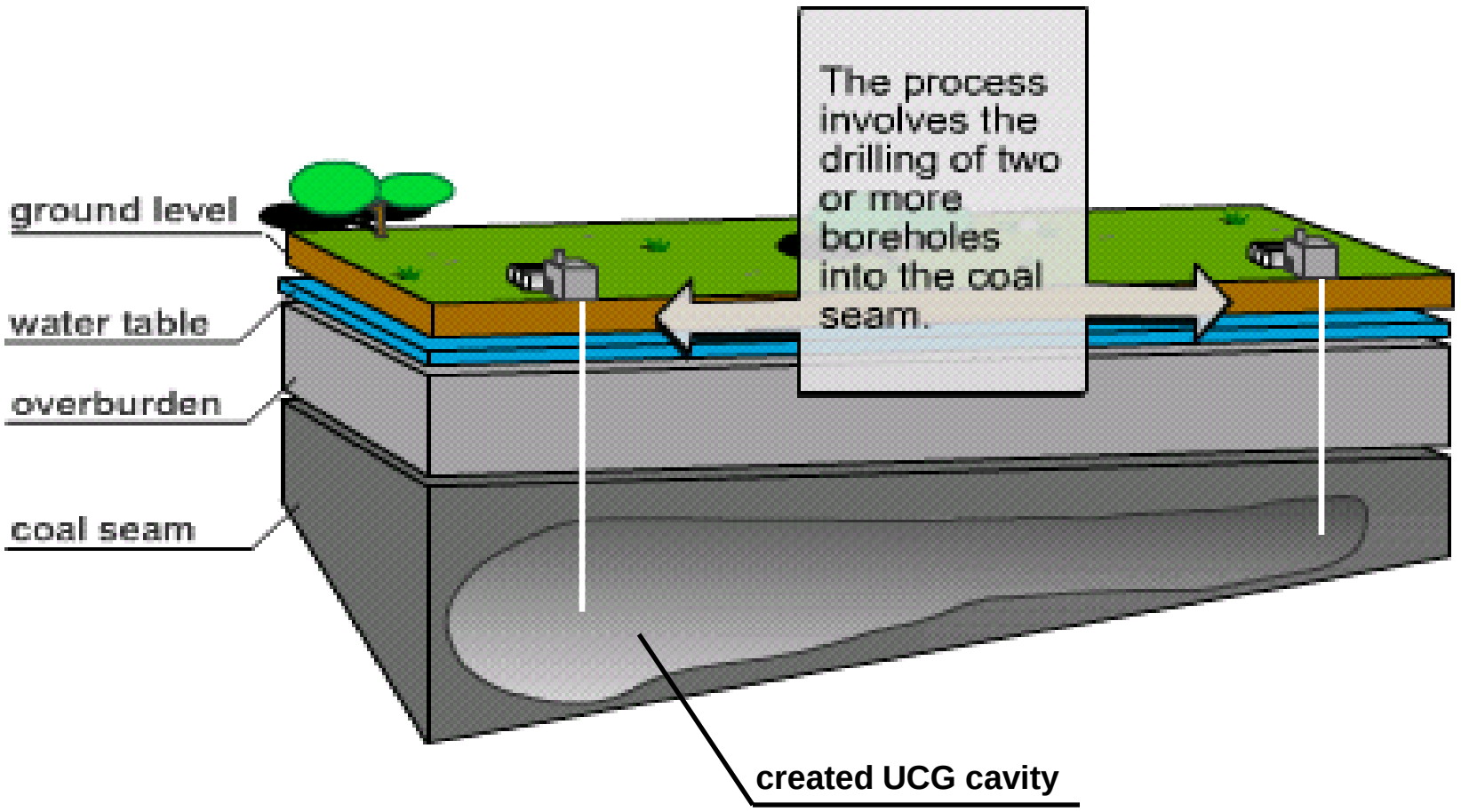
Underground Coal Gasification (UCG) is a cost-effective environmental friendly solution for resource recovery in areas beyond the technical and economic confines of conventional mining.

Employing a series of wells, UCG converts in-situ coal into product gas, thus eliminating the expense of:

- Mining
- Blending
- Stockpiling
- Reclamation
- Road transport
- Screening
- Fine coal losses and dust pollution
- Surface gasifier operation and mair
- Ash handling



THE UCG PROCESS - i



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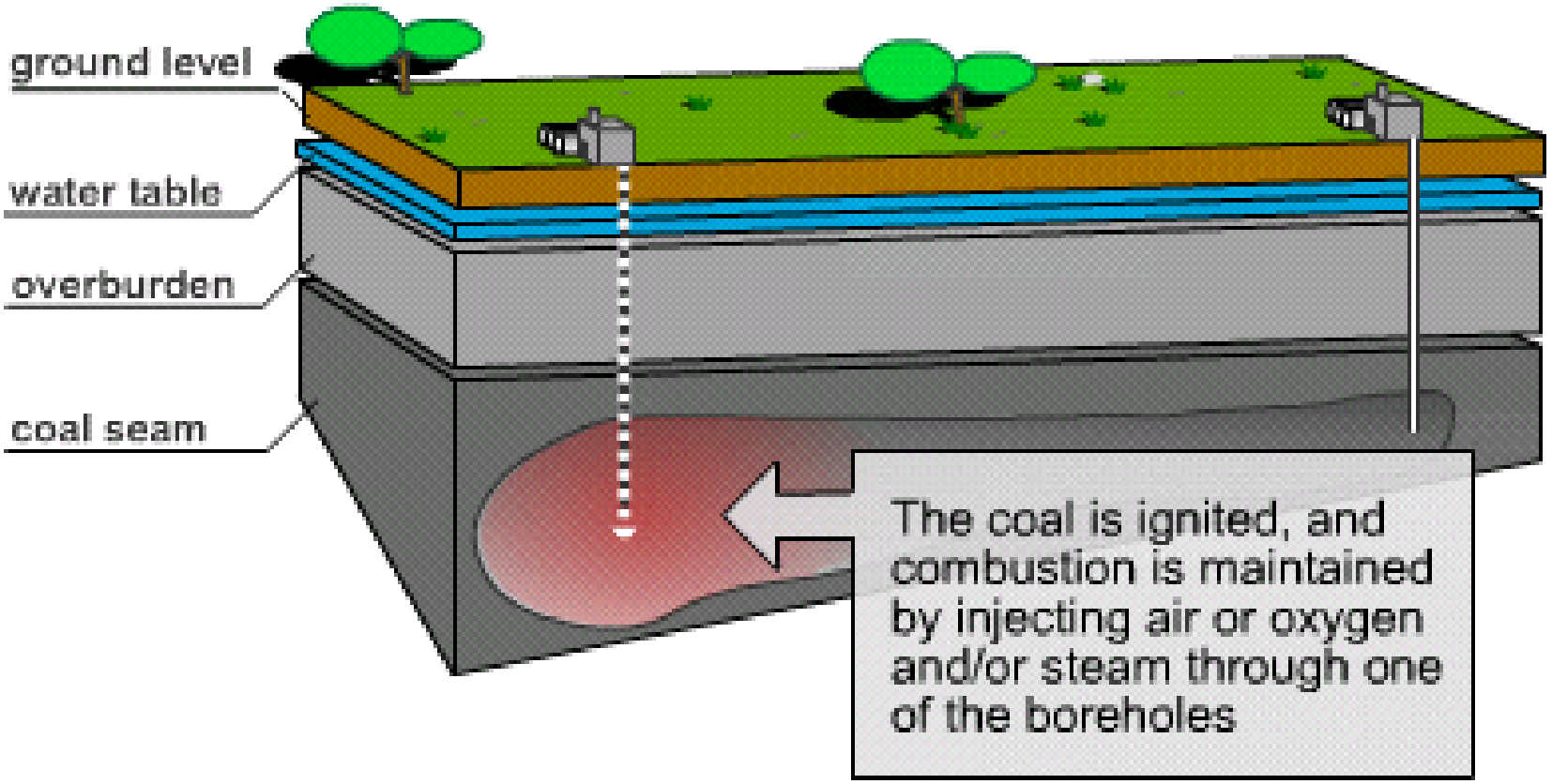
THE UCG PROCESS - ii



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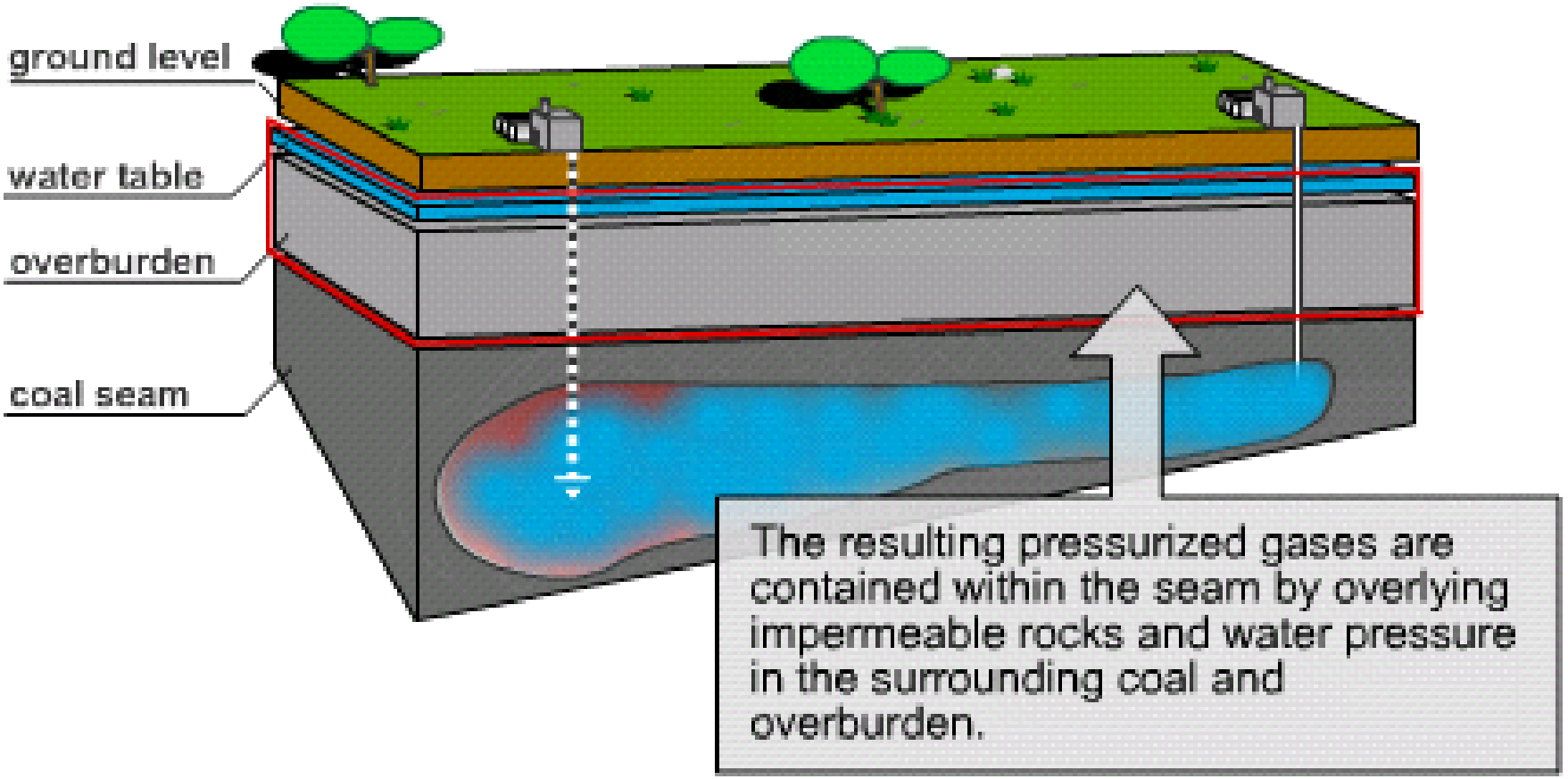
THE UCG PROCESS - iii



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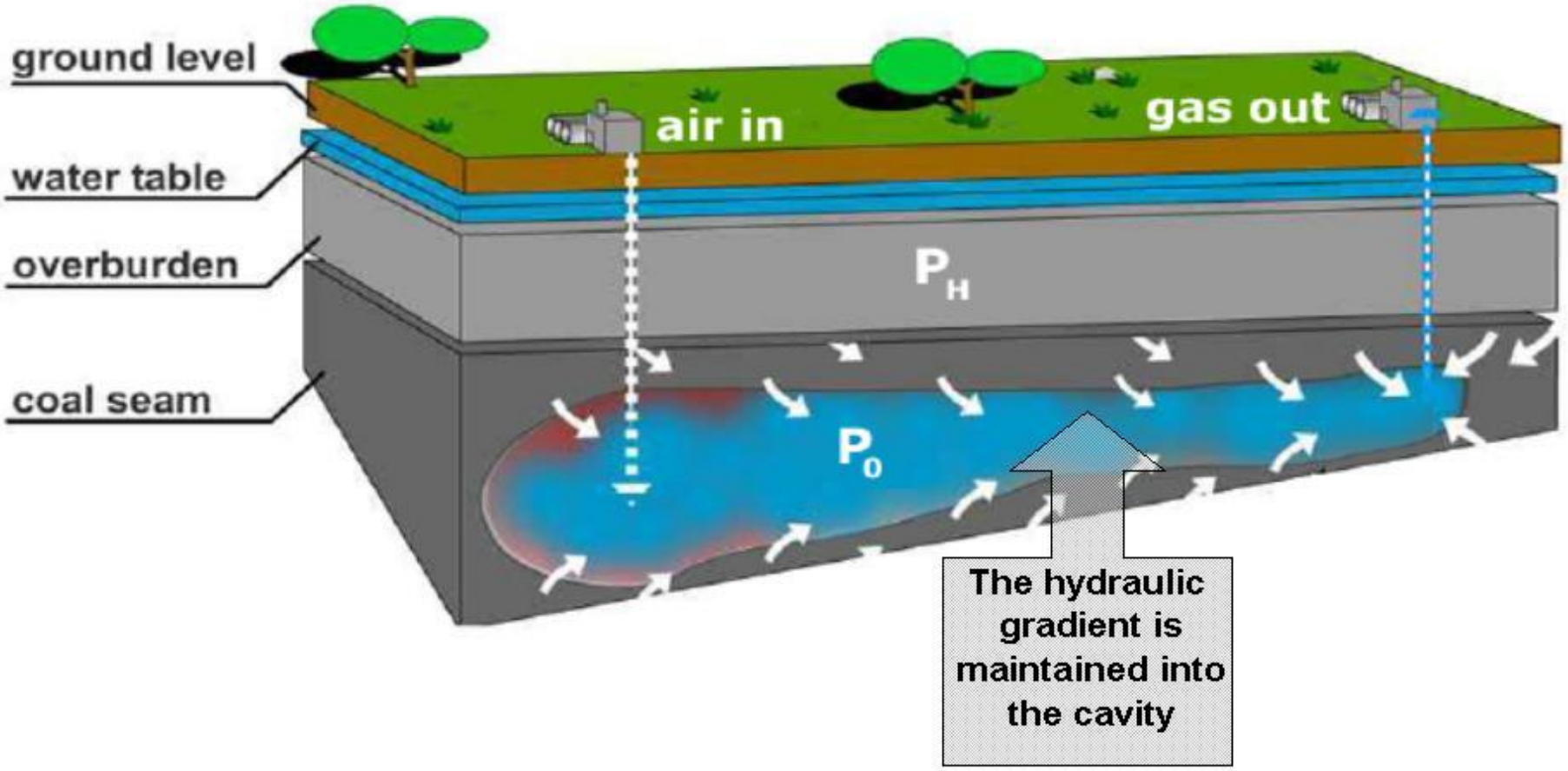
THE UCG PROCESS - iv



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Quick Process Description

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- UCG involves injecting steam and air or O_2 into a coal seam from a injection well. The injected gases react with coal to form a combustible gas which is brought to the surface in a production well, cleaned and used as a fuel or chemical feedstock.

- To facilitate flow of the gas through the coal seam from the combustion zone to the production well, a “link” is created by using directional drilling.

- At the initiation of a UCG operation, ignition wells are used to provide ignition agents (e.g. propane or LPG, burning wood or coal, ammonium nitrate fuel oil (ANFO), explosives like thermite, diesel and other fuels, air/steam/oxygen, etc.) to initiate combustion.

- Once combustion is established in the coal seam, the injection wells inject O_2 to sustain and control the combustion rate.

- A cavity is formed as the coal burns and the roof collapses / goaf. This results in lateral growth and is allowed to continue until the product gas quality deteriorates.

Quick Process Description

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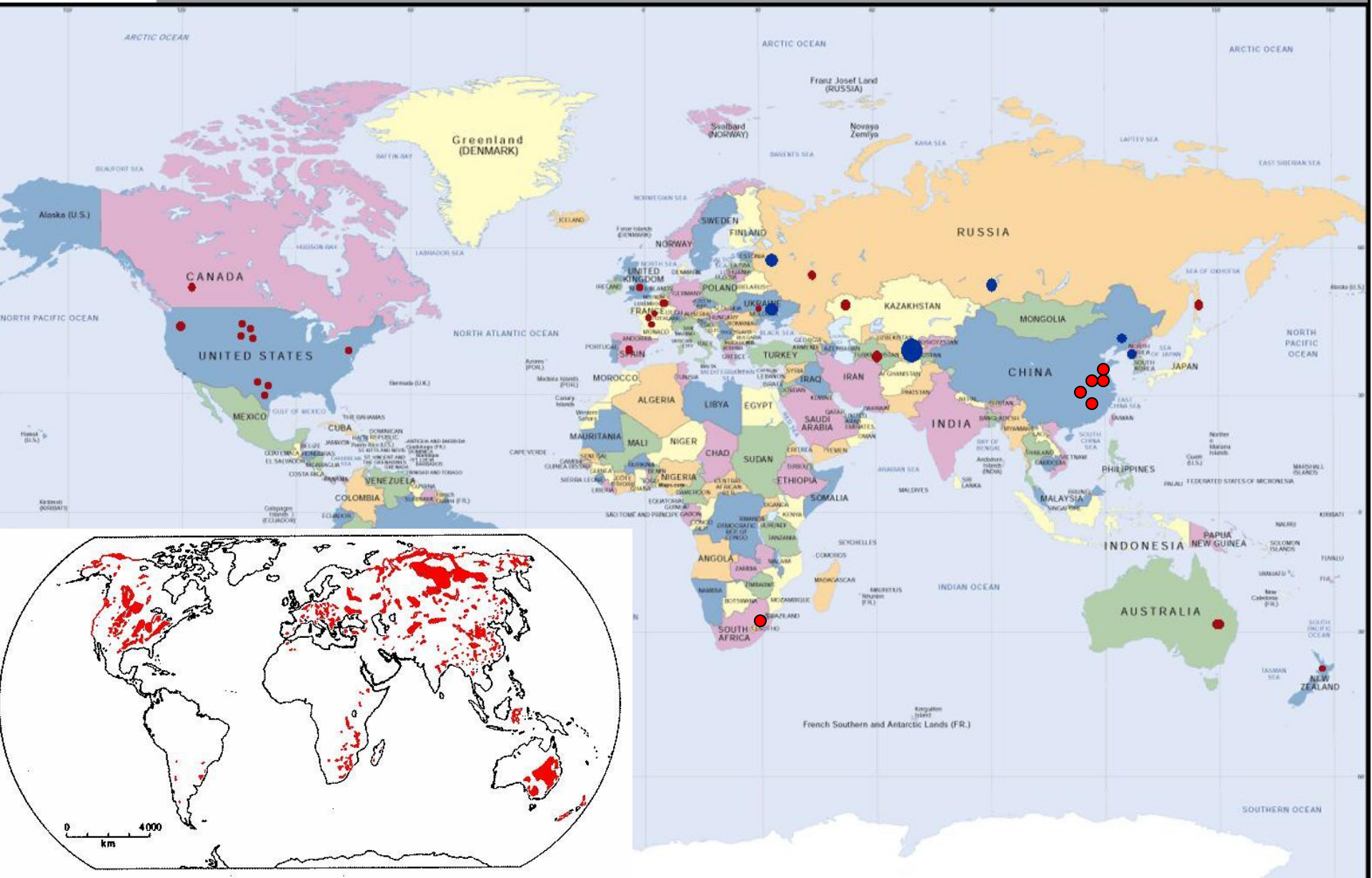
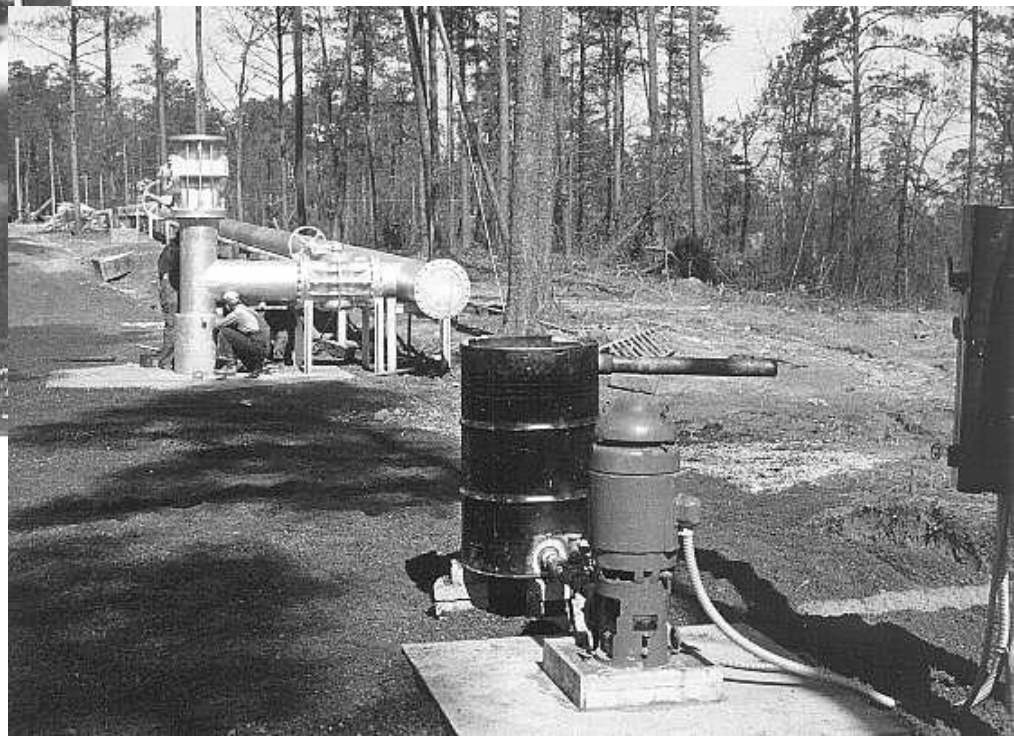
- Between the combustion zone and the production wells, the gas flows through the coal seam and is enriched by products of the reactions and pyrolysis.
- When the quality of the product gas falls, fresh coal is ignited further along the injection well. The Injection Wells are often moved in order to “guide” the combustion process between the wells and thereby create the desired link between the reaction zone and the production well.
- The greater the lateral growth, the longer the life of a gasifier and the more cost-effective the operation.
- Once the coal within the underground gasifier has been exhausted, new injection and production wells are drilled and the process is repeated.

Worldwide distribution of UCG sites



Gorgas, USA - 1950's



ERGO EXERGY INC

Angren, Uzbekistan

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[UCG - 1956 to present, 100 MW_e, gas + coal]

ERGO EXERGY INC
- All Types of Coal

UCG plant	Coal rank	Thickness m	Depth m	Dip °	Net Heat Value MJ/kg
Lisichansk	Bituminous	0.44 - 2.0	60 - 250	38- 60	20.1 -23.0
Yuzhno-Abinsk	Bituminous	2.2 - 9.0	130 -380	35 - 56	28.9 - 30.7
Podmoskovnaya	Lignite	2.5	30 -80	0	11.8
Angren	Subbituminous	3.0 - 24.0	110 -250	7	15.3
Shatskaya	Lignite	2.6	30 - 60	0	11
Sinelnikovo	Lignite	3.5 - 6.0	80	0	8

Former-Soviet Union UCG R&D started in the 1930's, went commercial in 1950's

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Huntley, NZ

Rawlins 2, USA 1980

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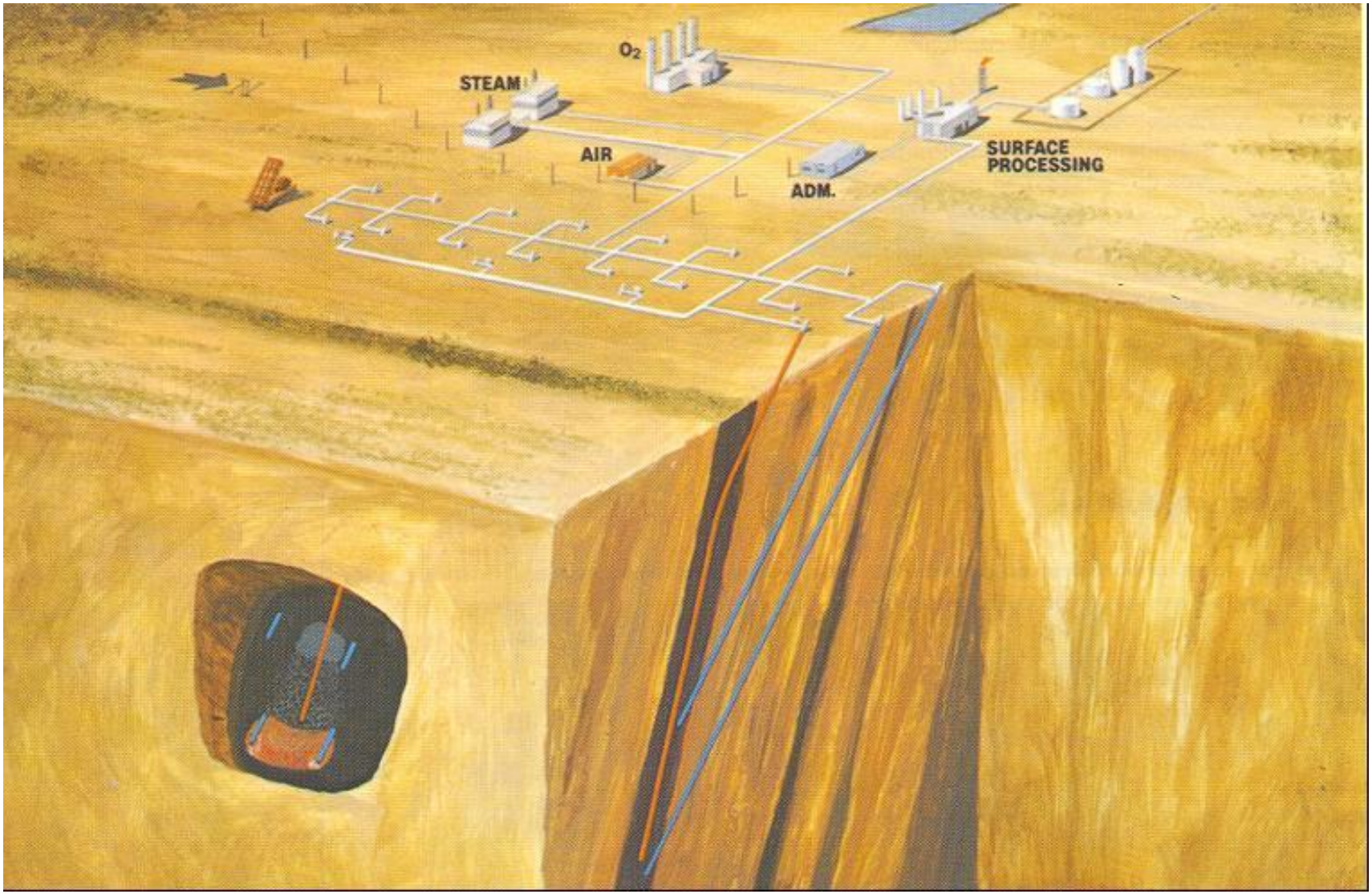
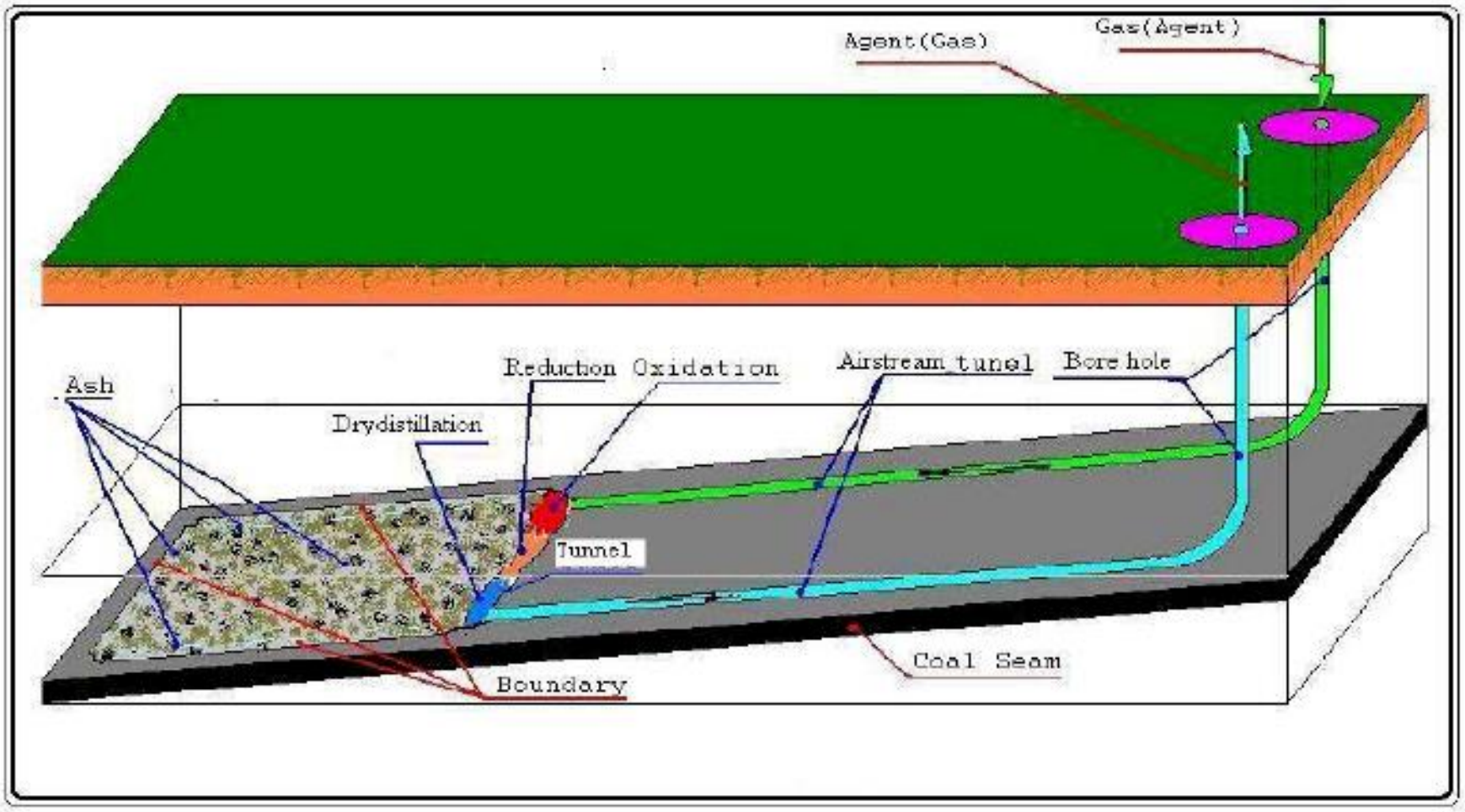
A Look at Steeply Dipping Bed (In Situ Energy - ISE)



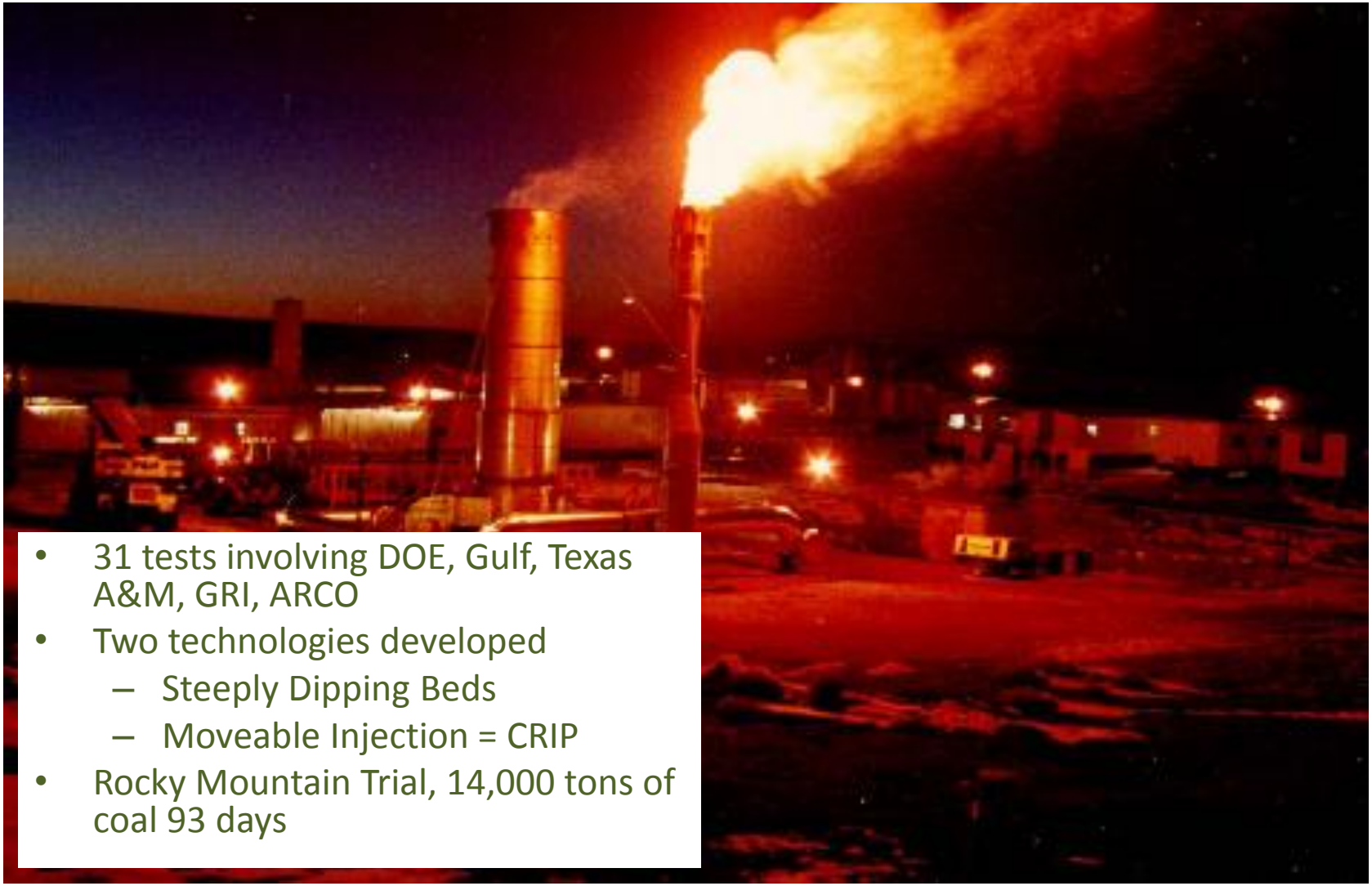
Zhangzhuang UCG Station

XinAo Group, *China, 1990 to present*

The sketch of the "long-tunnel, large-section, two-stage" gasifier



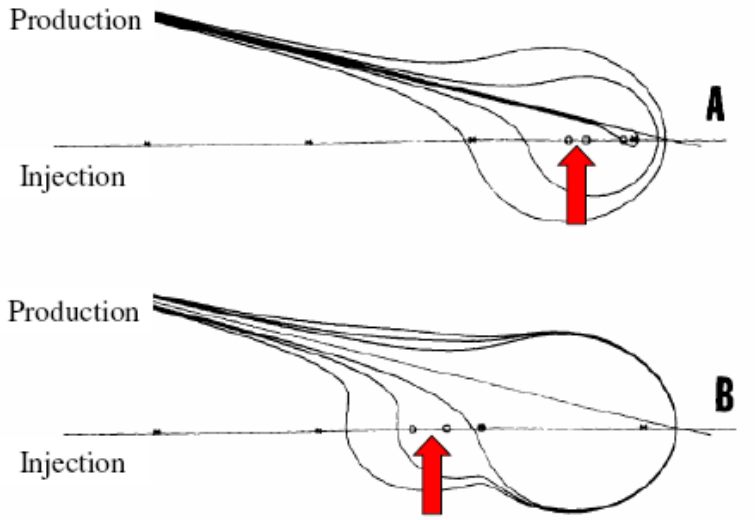
Rocky Mountain, US Trials 1987-1990



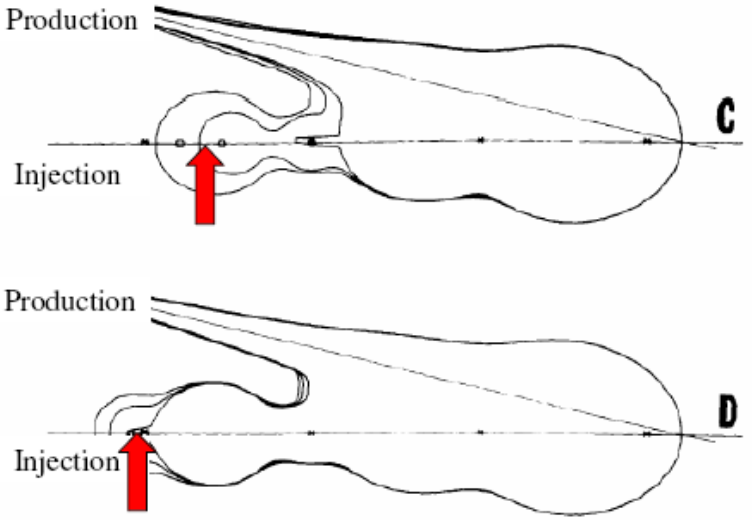
- 31 tests involving DOE, Gulf, Texas A&M, GRI, ARCO
- Two technologies developed
  - Steeply Dipping Beds
  - Moveable Injection = CRIP
- Rocky Mountain Trial, 14,000 tons of coal 93 days

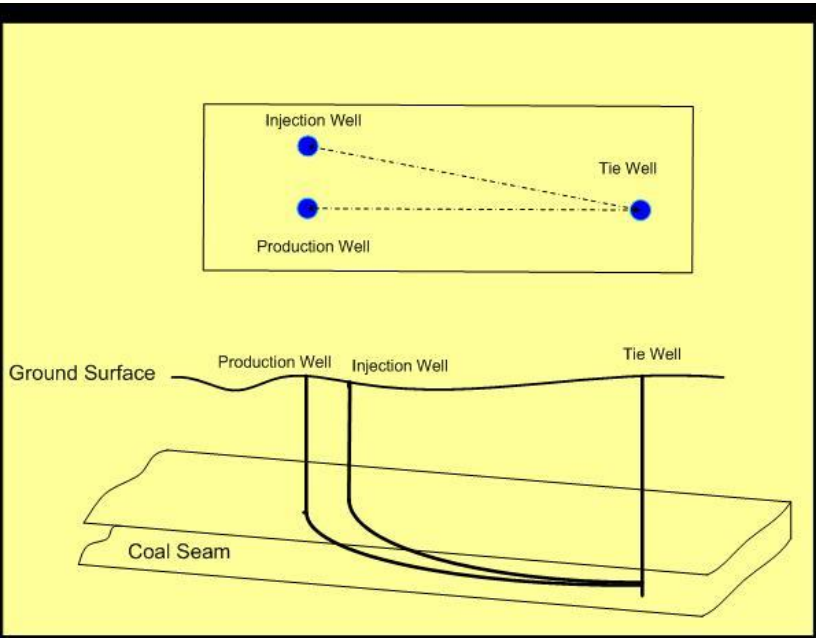
Joint European Trail, Spain

Cavity growth (Experimental) 1



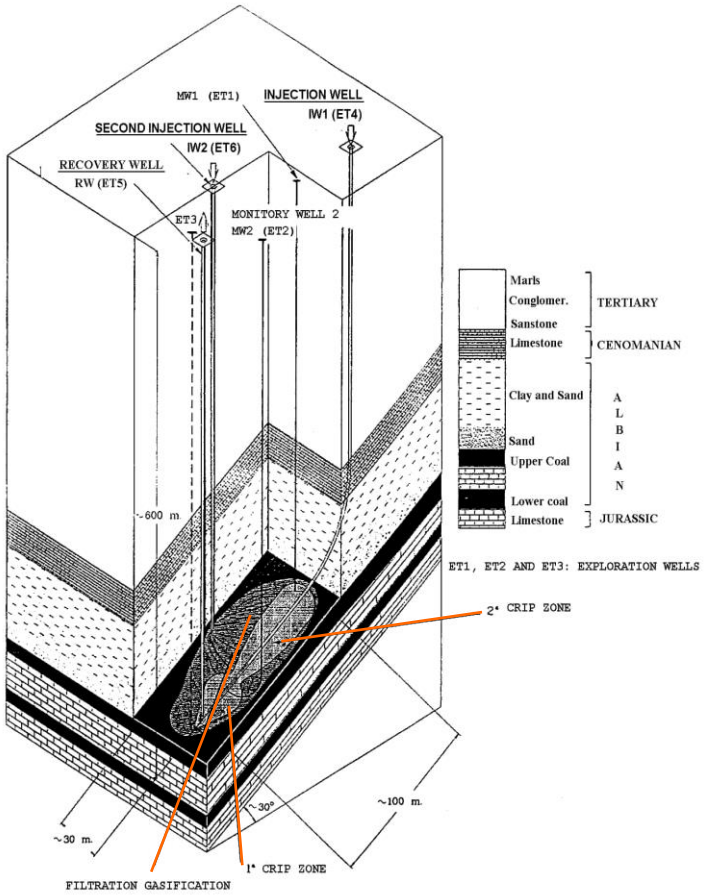
Cavity growth (Experimental) 2





- ELW is 2 directionally drilled wells that intersect at an angle of 30º.
- Combustion was started at the intersection point from a vertical borehole, but it was assumed that in future this could be done through one of the directional boreholes
- One directional hole is used as injection hole and the other as Production hole.
- Gasifier life was short lived as chamber dies as it reached maximum sustainable size.
- Once dead it could not be started again

Well Layout for Spanish Trial (CRIP)



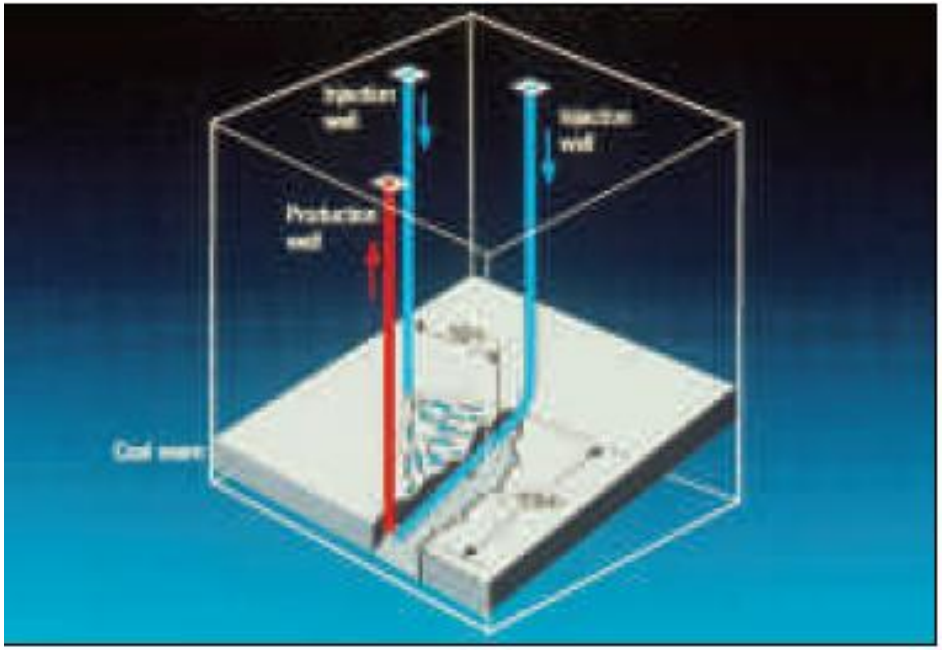


FIGURE 5 Well Layout

THE CHINCHILLA PROJECT

Queensland, Australia

- pilot scale
- operating Nov 1999 – Apr 2003 (in conservation mode at present)
- conversion to CTL proposed
- little visible infrastructure
- no groundwater /surface contamination *
- no surface subsidence
- 1 week shutdown possible i.e. peaking capability with CCGT
- 100% availability
- 95% coal usage
- 75% energy recovery

* By independent audit by Golder Associates, for Australian EPA

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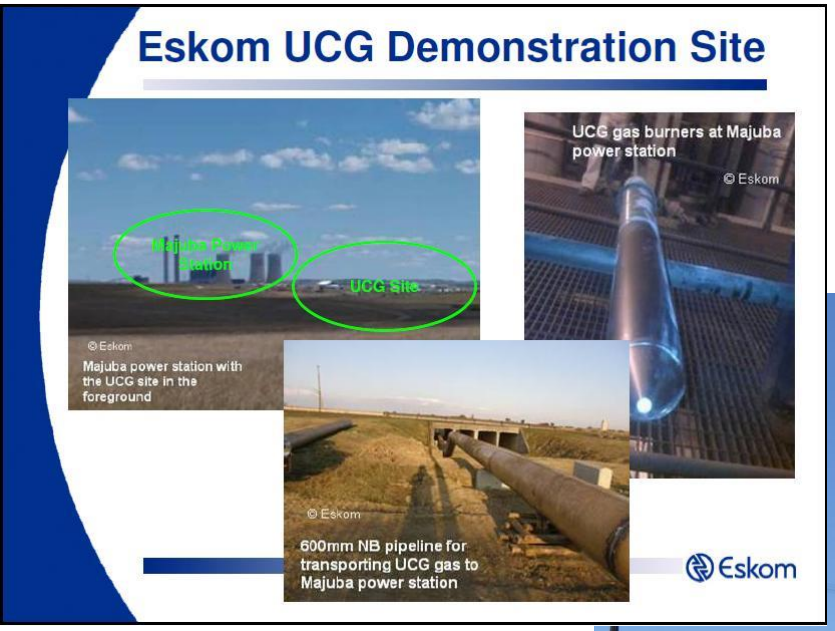
Chinchilla, (1999 to present)

And then a stone's throw from us… Eskom Surface infrastructure



Picture by: Eskom
The gas-treatment plant at Majuba

UCG Schematic model

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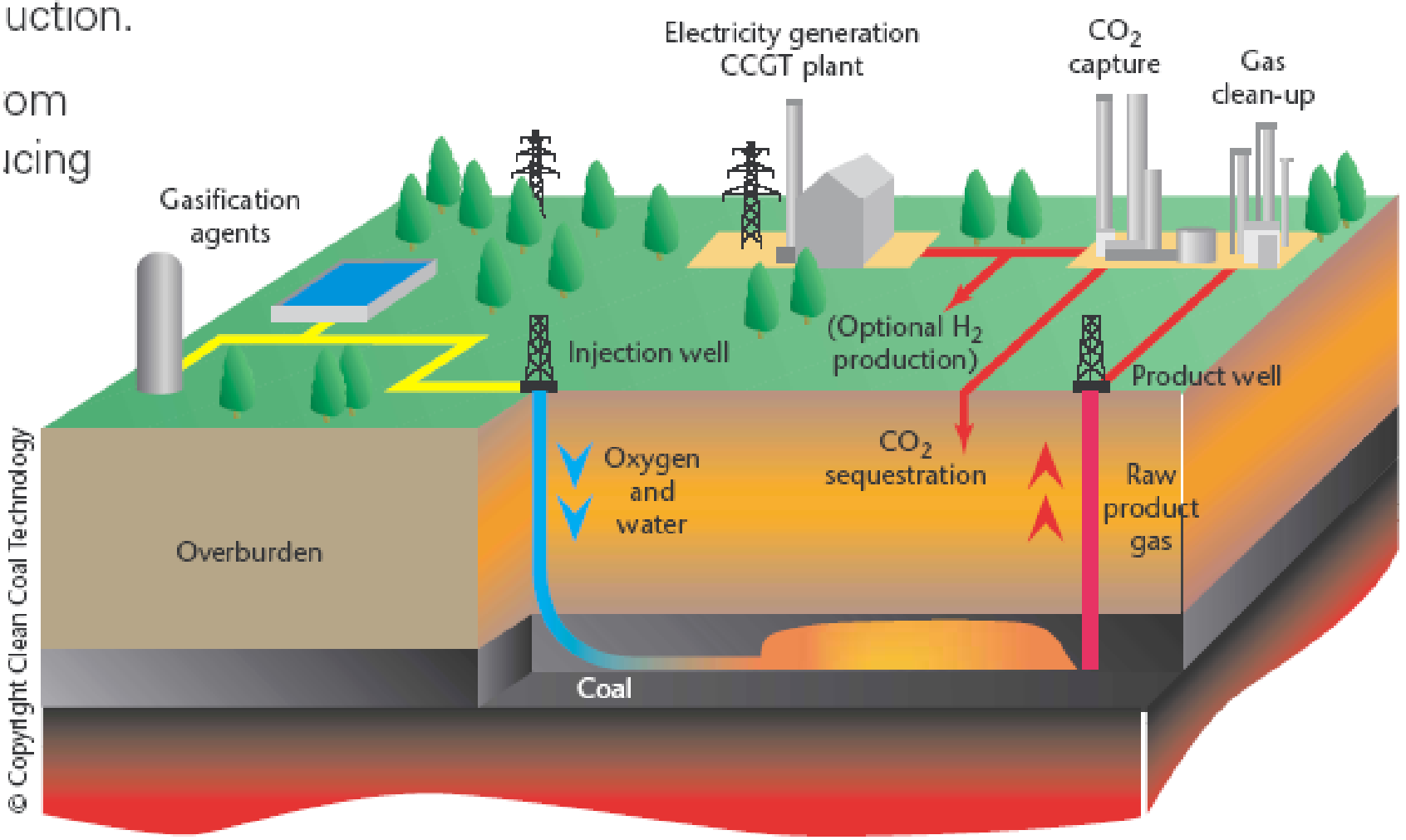

Technology diagrams

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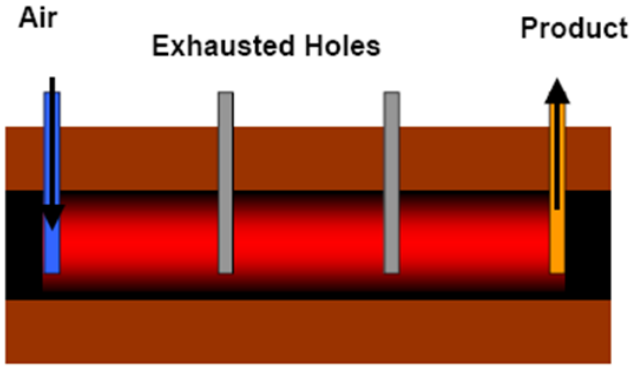
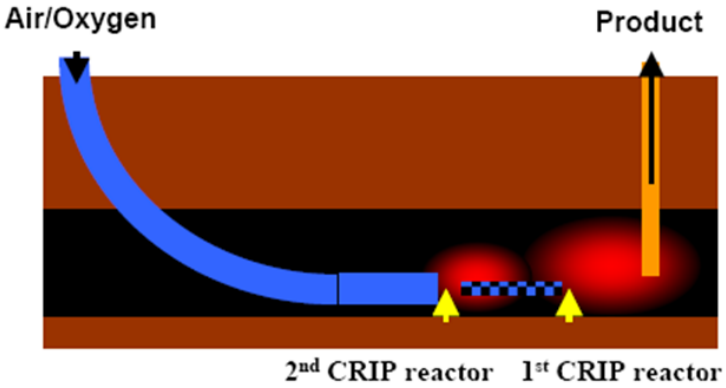
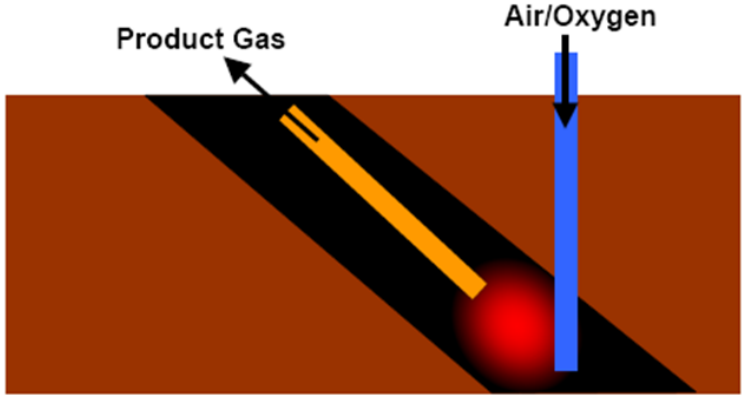
Vertical Wells



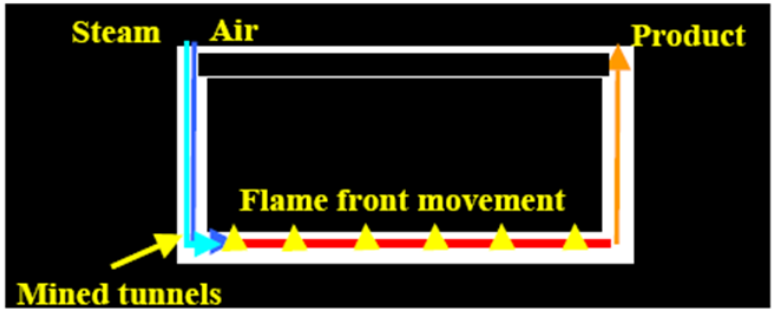
CRIP
(Controlled Retracting Injection Point)



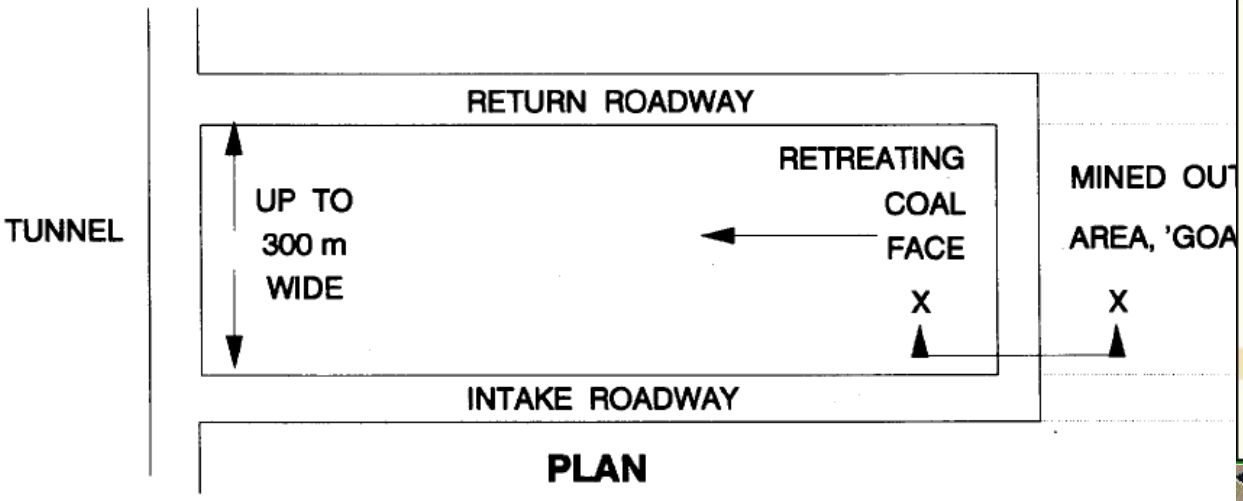
Steeply Dipping Bed

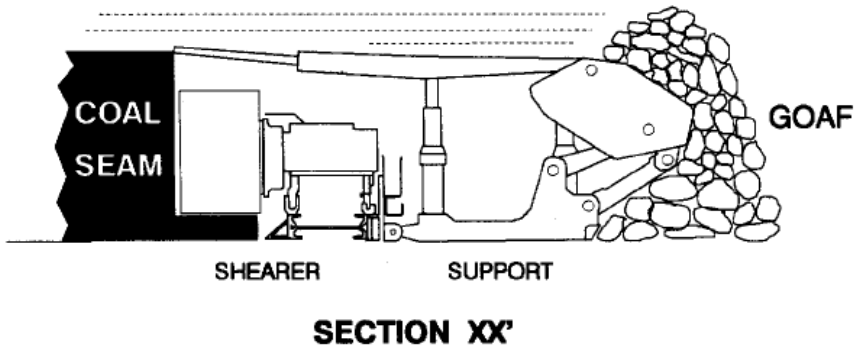


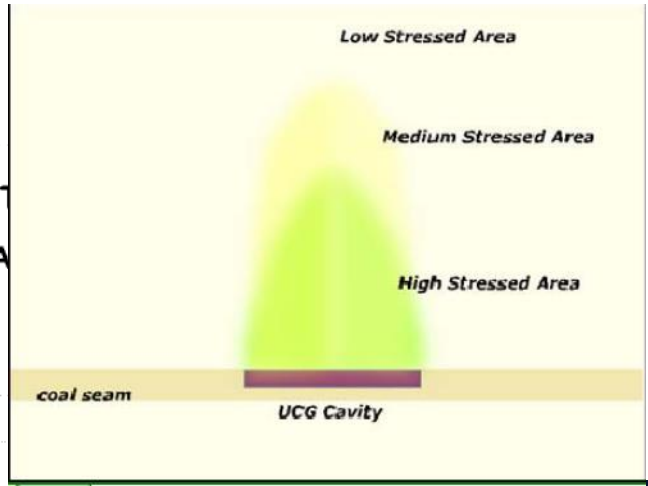
Tunnel

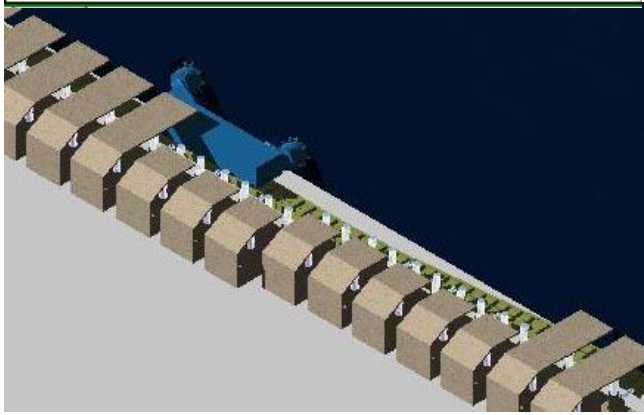


Long-wall mining thinking applied to UCG



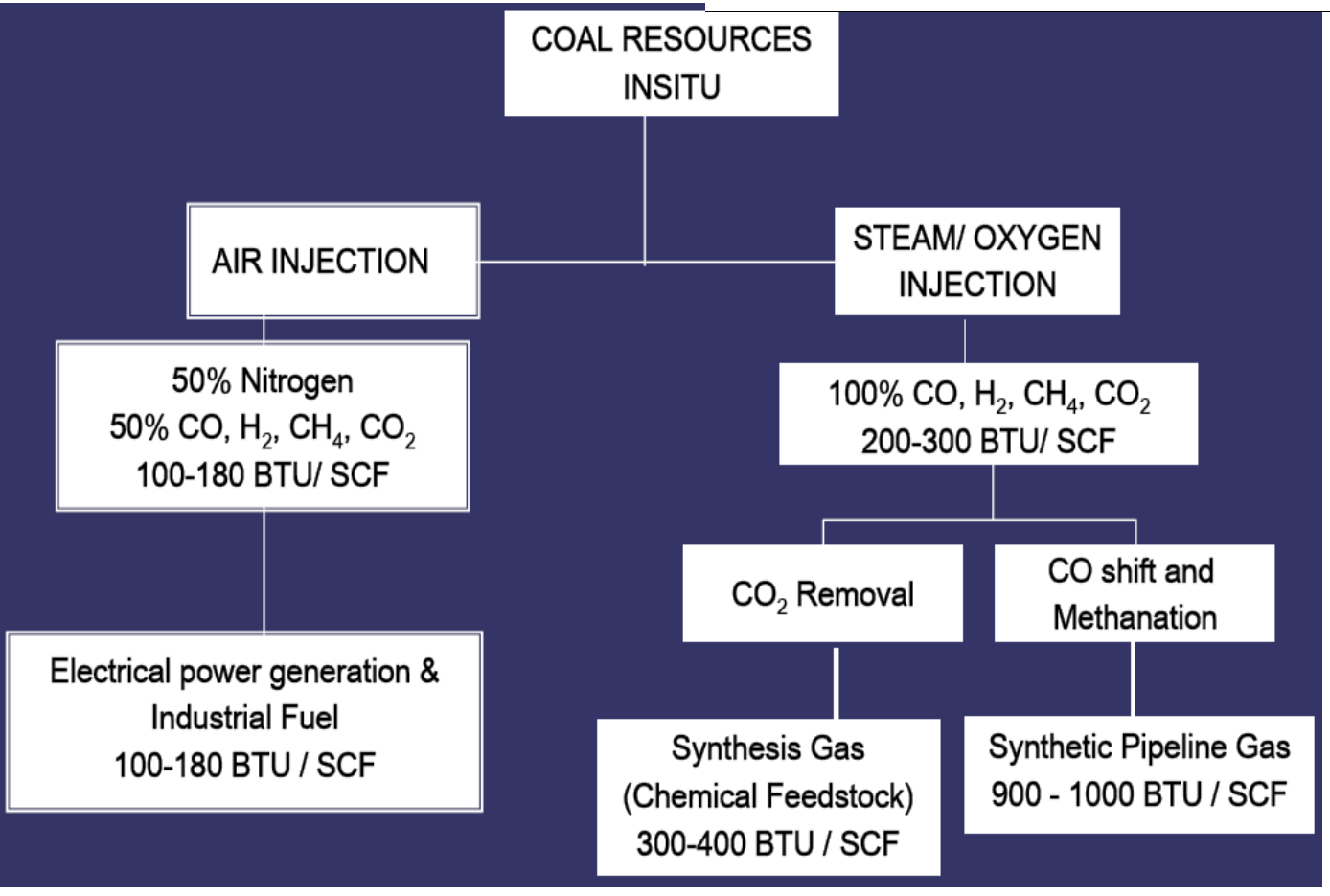






Why Air vs. O_2

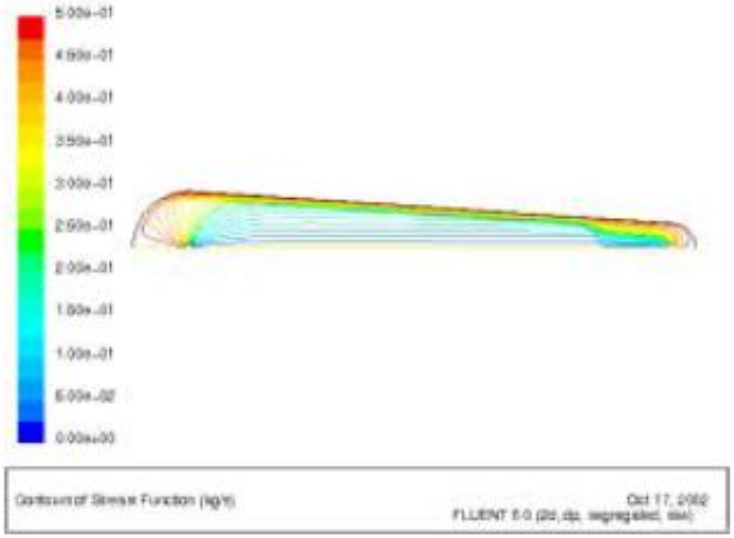
Process	Efficiency
Air-blown UCG	45.4 %
Oxygen-blown UCG	46.5 %
UCG with CO_2 separation	39.8 %
Conventional coal	~37 %
IGCC	~45 %

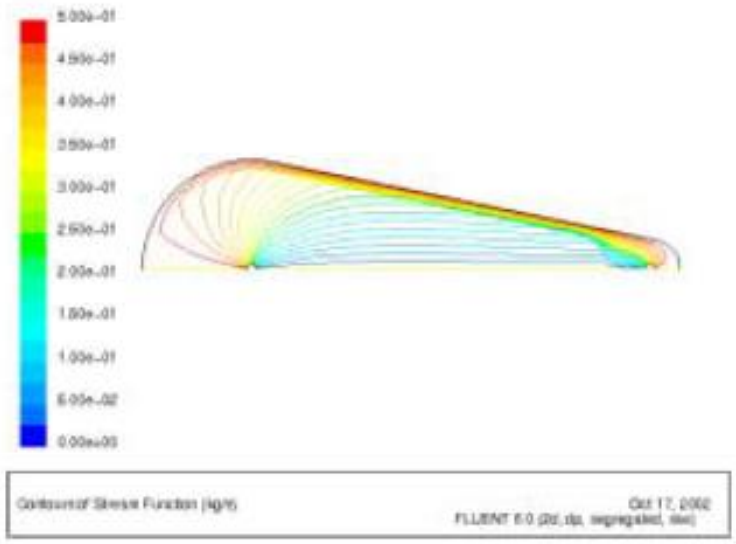


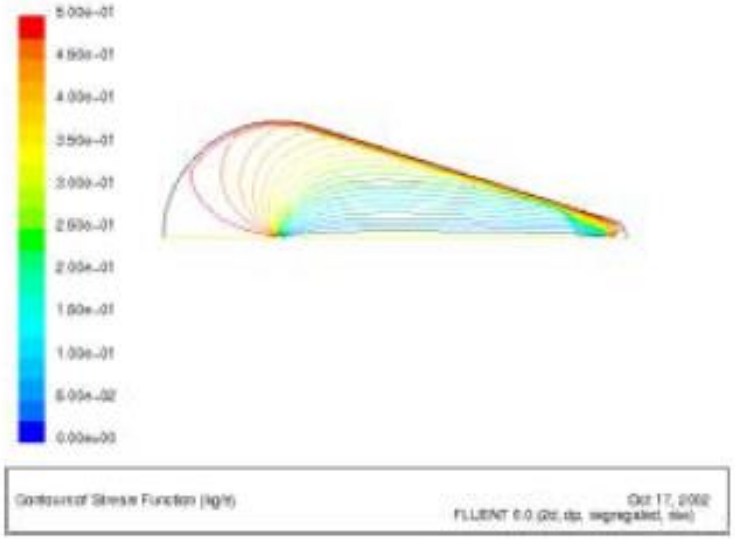
Oxygen is better for:

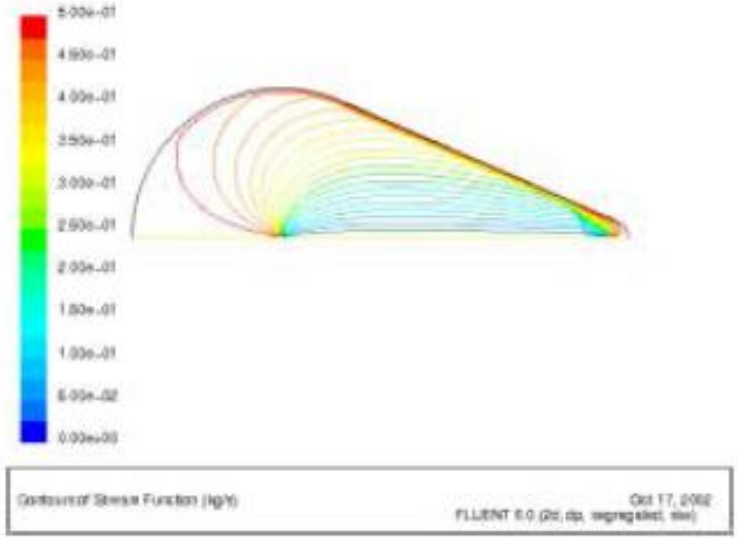
- **Increased CO:CO_2 ratio**
- **Improves CV**
- **Improved gasification stability**
- **Better cavity growth**
- **60% reduction in volume of compressed gas injected into seam**

Isothermal Flow Modelling



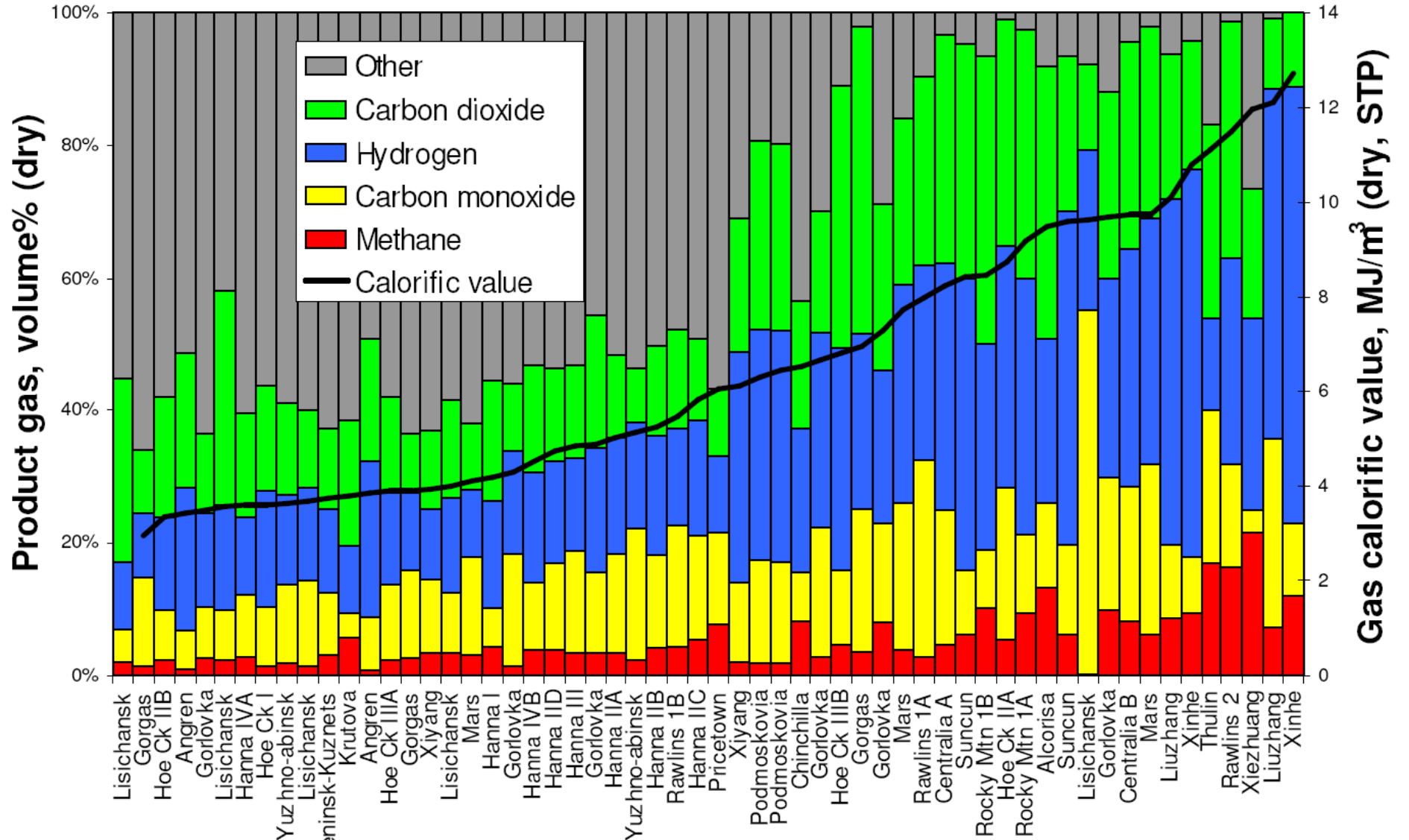




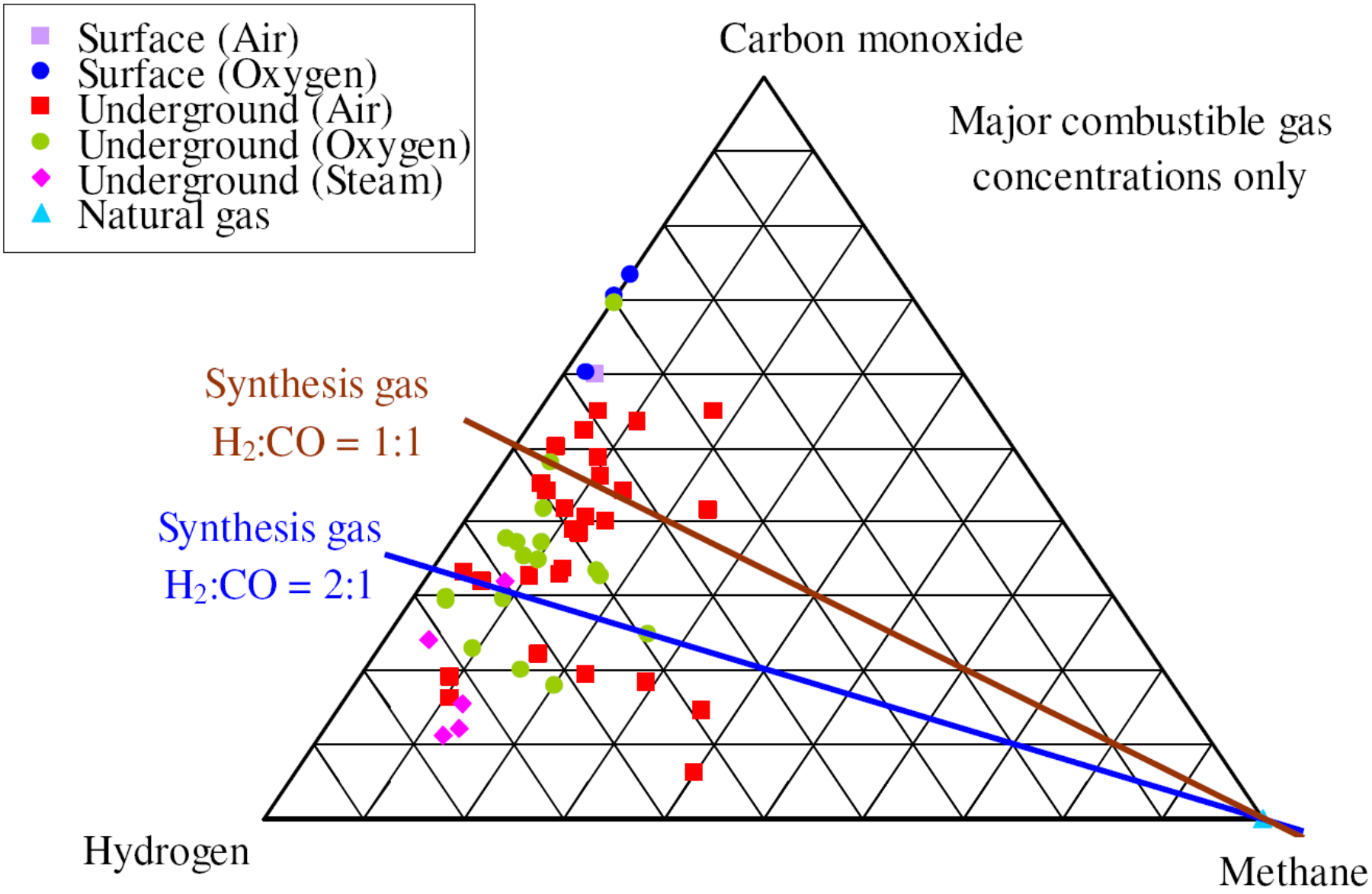


Copied from: UK symposium on UCG 2003 Presentation on Underground Coal Gasification Modeling by Greg Perkins

Variability in historical data



Another way of looking at it…



Opportunity definition for UCG

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1. Utilisation of isolated deep coal reserves which can not be otherwise economically exploited

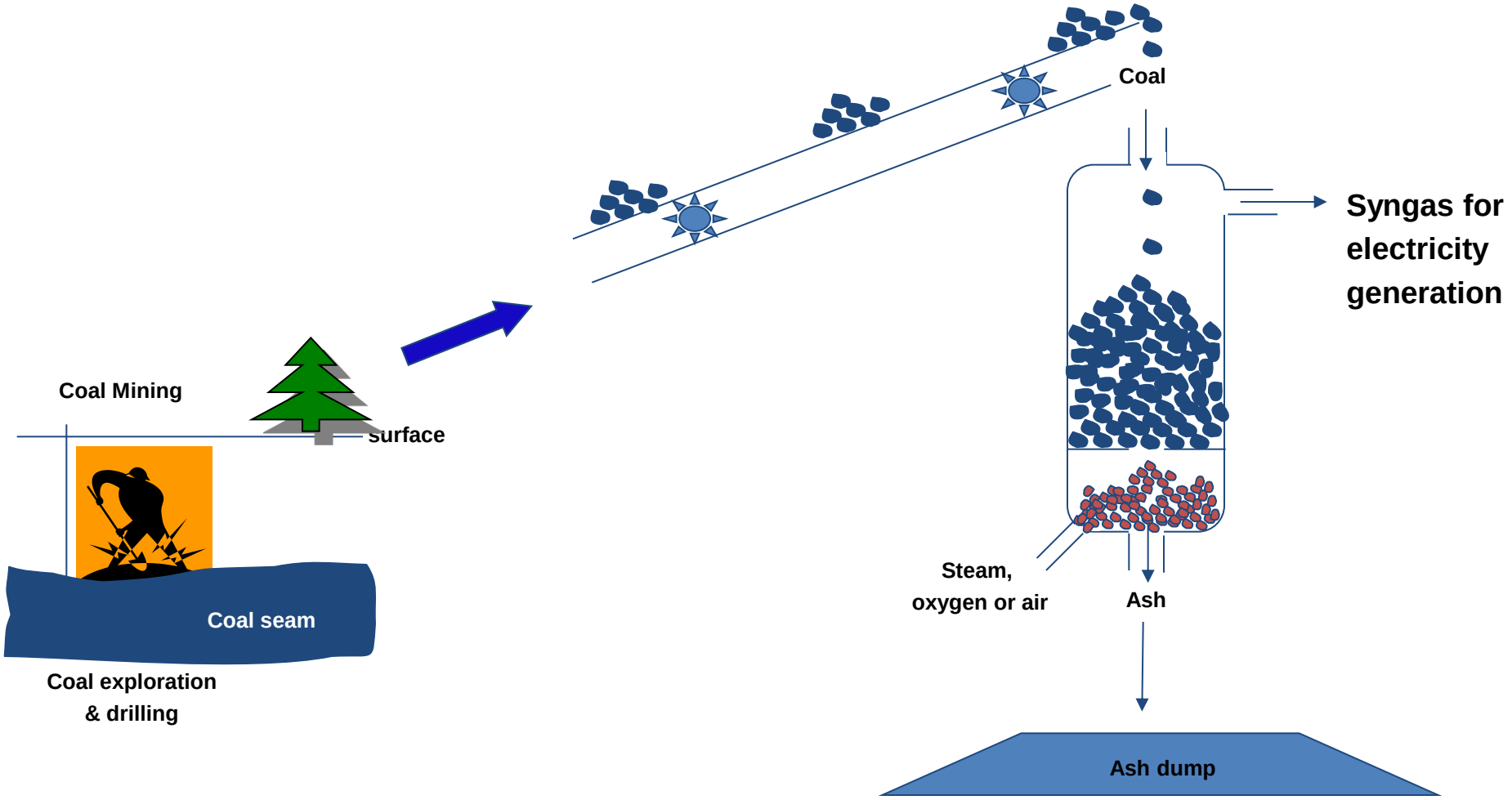
2. Increased efficiency of fossil fuel use (up to 95%)

3. Extension of mine life through optimal coal utilisation

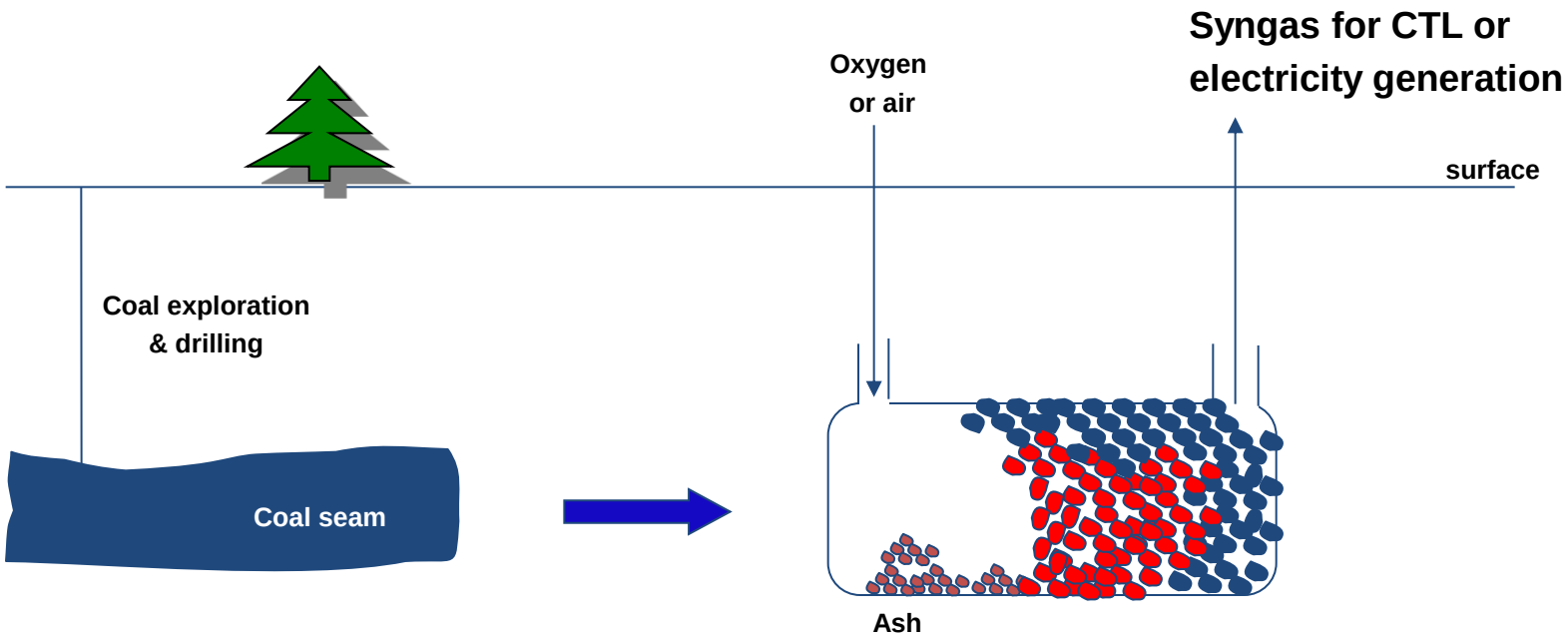
4. Reduction of environmental footprint (no coal or ash handling required)

5. Mining-related hazards are avoided

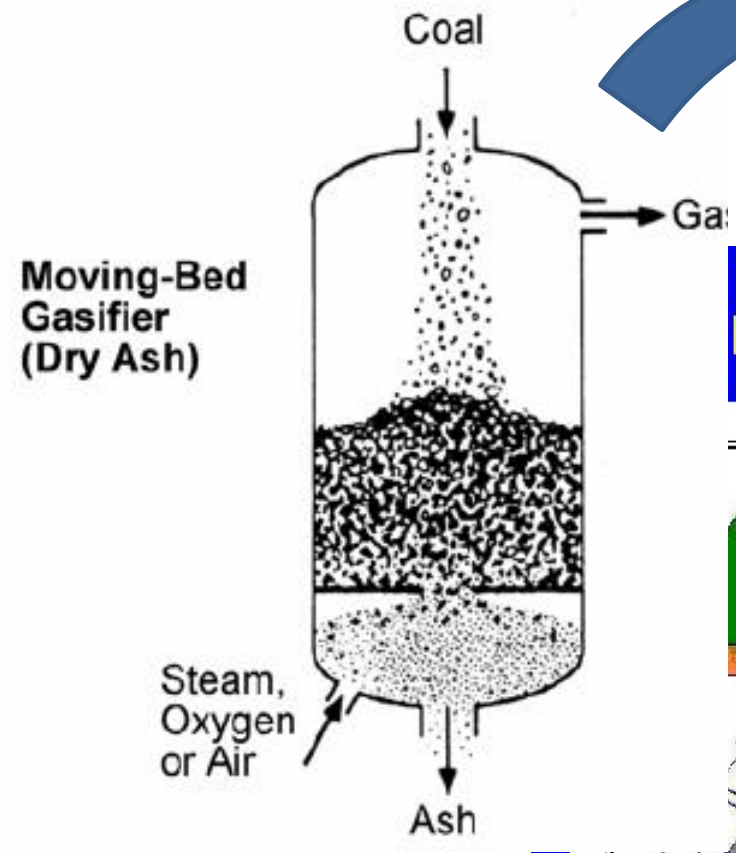
Current above ground gasification processes

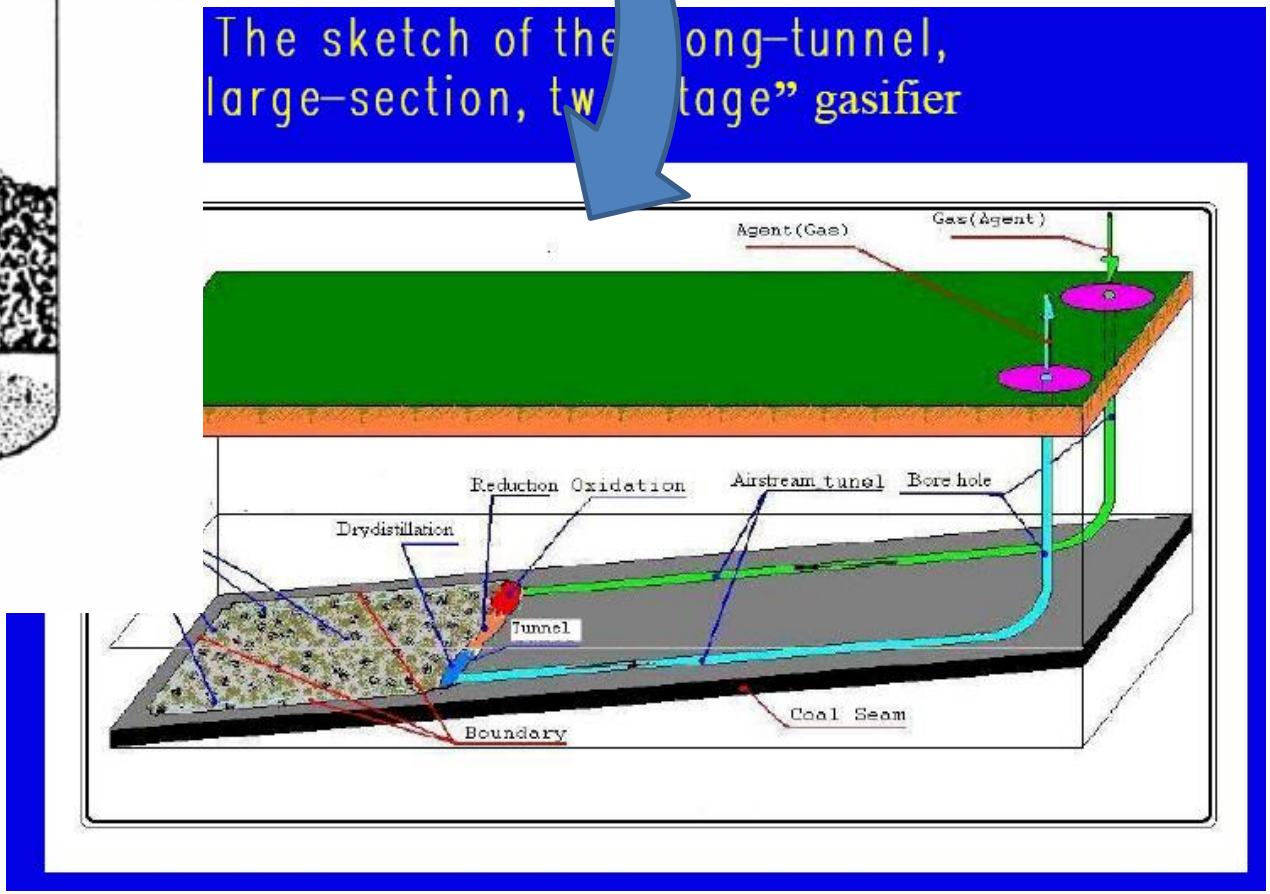


With UCG, the same coal gets gasified

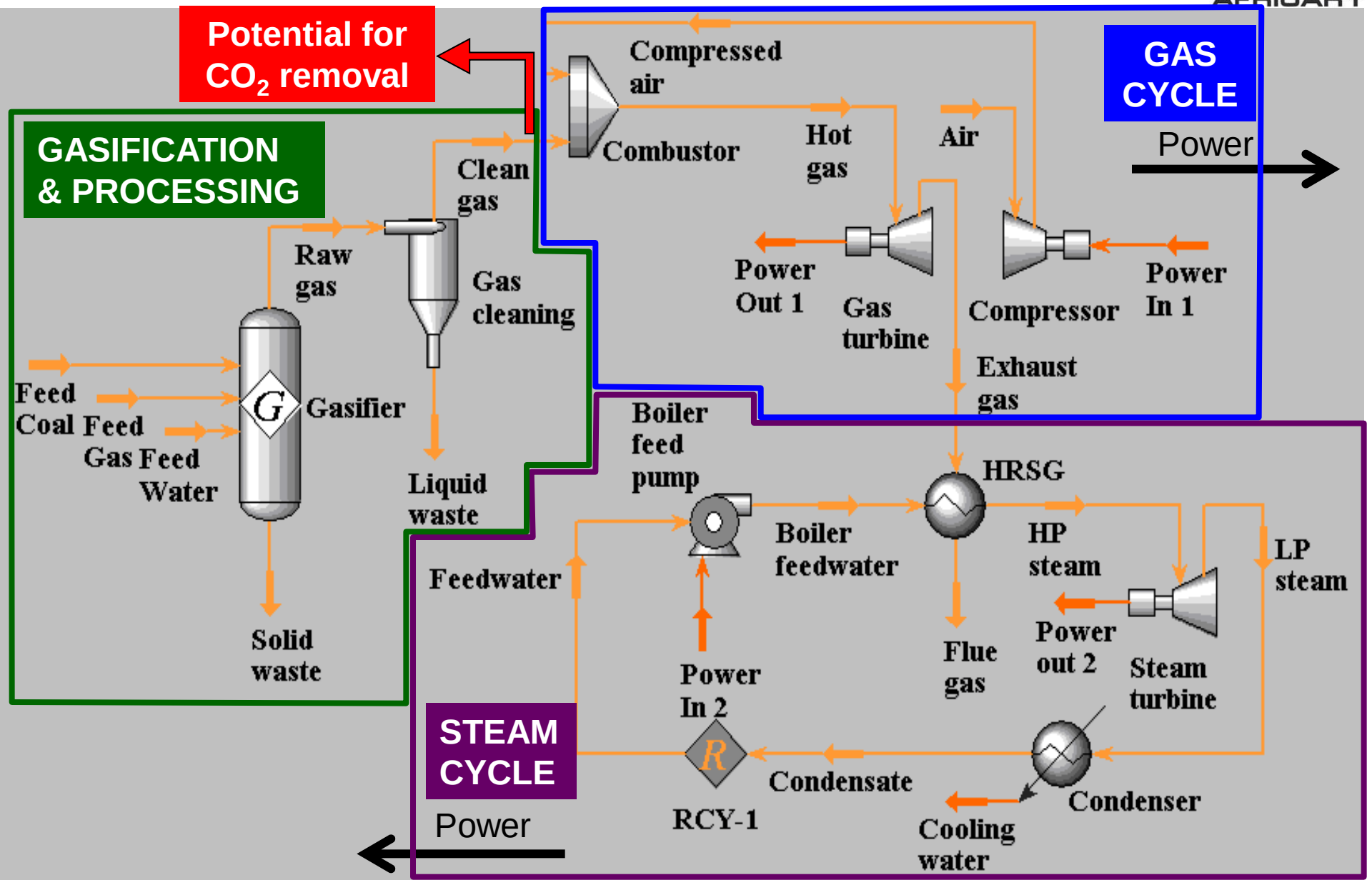


Above ground versus under ground





The electricity generation process



Low Cost Low Emission Power

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