UCG History

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Outline

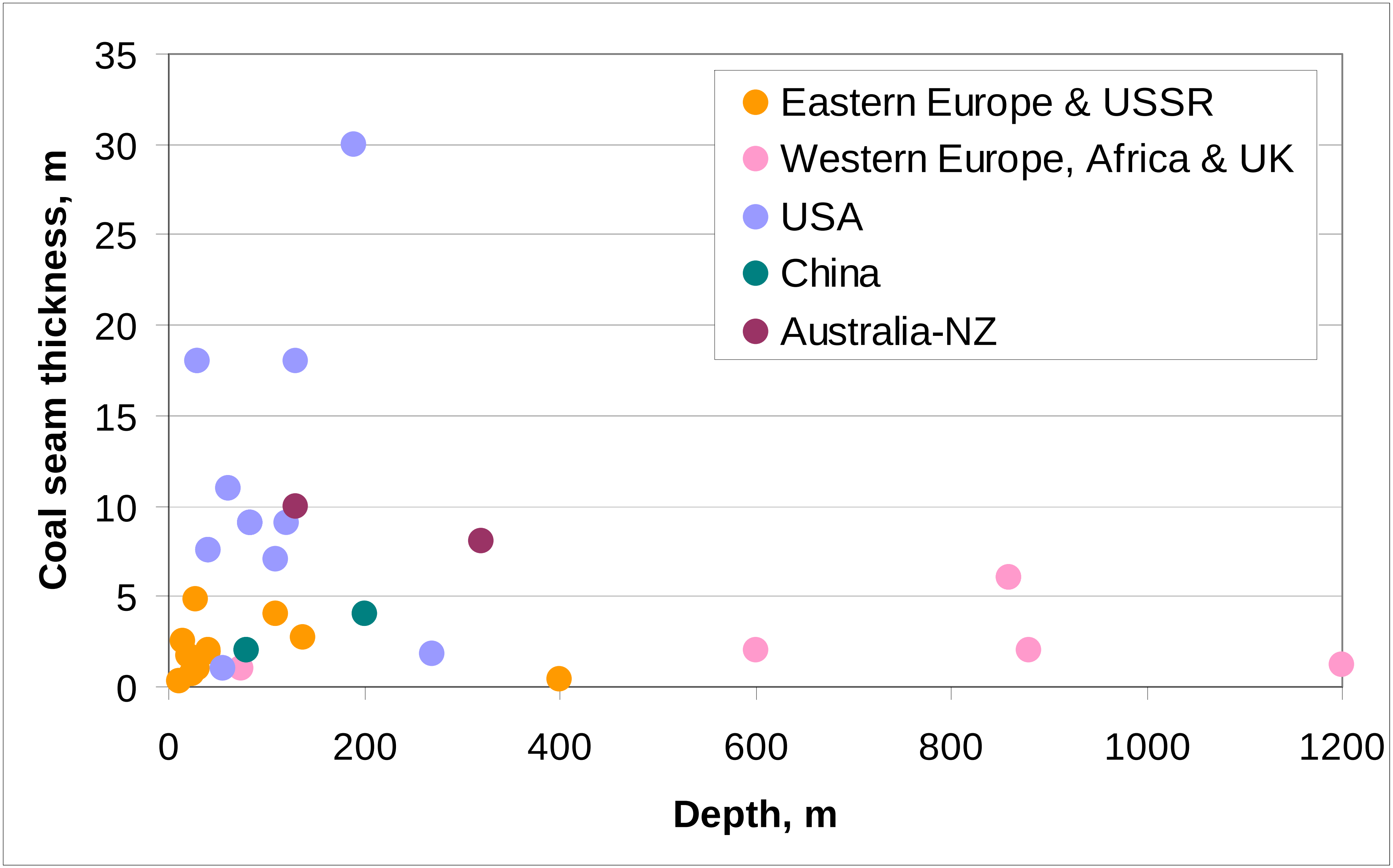
- ❖Introduction
- ❖Worldwide summary
- ❖Former Soviet Union
- ❖United Kingdom
- ❖USA
- ❖Europe
- ❖China
- ❖Australia

Introduction

- Underground coal gasification has been performed at over 50 sites worldwide since the 1930s
- Operations in the former Soviet states dominate in terms of quantities of coal gasified and the range of coal seam characteristics used
- Gasification sites over 600m deep have been used in Western Europe

Distribution of UCG sites

Site characteristics



Former Soviet Union

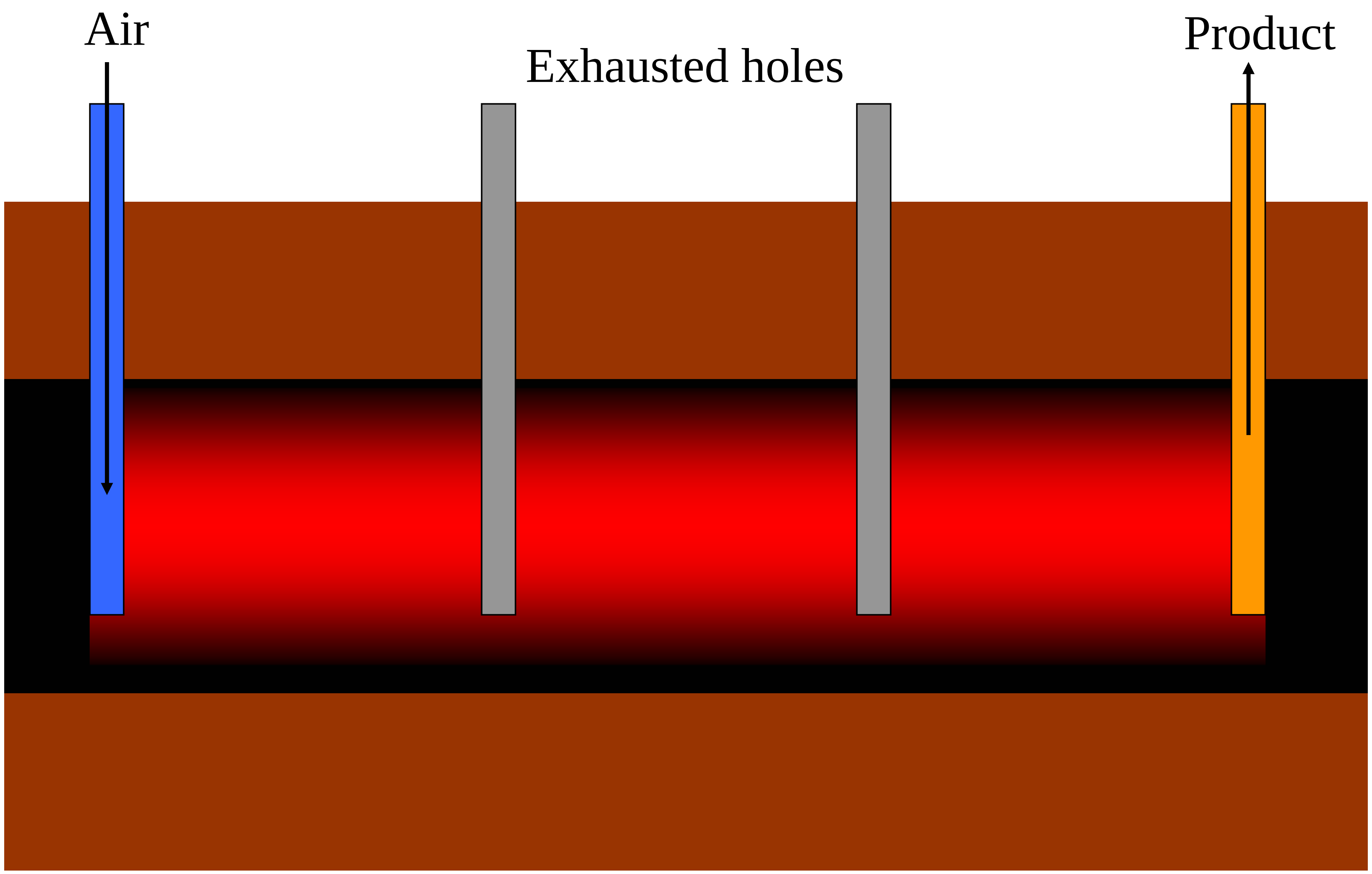
- ❖Research commenced in the 1930s with the target to demonstrate UCG in a wide range of coal seams
- ❖Large plants were under construction prior to WWII, but were abandoned
- ❖In the 1950s there was rapid expansion in use of UCG in many parts of the FSU
- ❖Most plants closed with the increasing availability of Siberian natural gas
- ❖Angren (Uzbekistan) and Yuzhno-Abinsk (Siberia) remain operational

FSU - Coals used

Summary of coal seam characteristics at Soviet UCG sites

Sites of UCG	Coal seam thickness m	Depth of occur-rence, m	Angle of dip, degree	Technical composition of coal			Low heat value, as received basis, MJ/Kg
				Moisture content as received,	Ash content, dry basis,	Volatile matter (Combustible mass)	
Coal							
Lisichansk	0.44-2.0	60-250	15-50	12 - 15	7 - 17	39-40	20-23
Yuzhno-Abinskaya	2.2-9.0	50-300	55-65	2.5-8.0	2.3-5.2	27-32	28-30
Brown coal							
Angrenskaya	2.0-22.0	120-250	7 - 10	35.00	12.20	33.00	15.10
Podmoskovna-	2.50	30-80	0-2	30.00	34.30	44.50	11.80
Shatsk	2.6-4.0	30-60	0-2	30.00	26.00	38.10	11.10
Sinelnikovsky	3.5-6.0	80.00	0-2	55.00	23.80	64.50	8.00

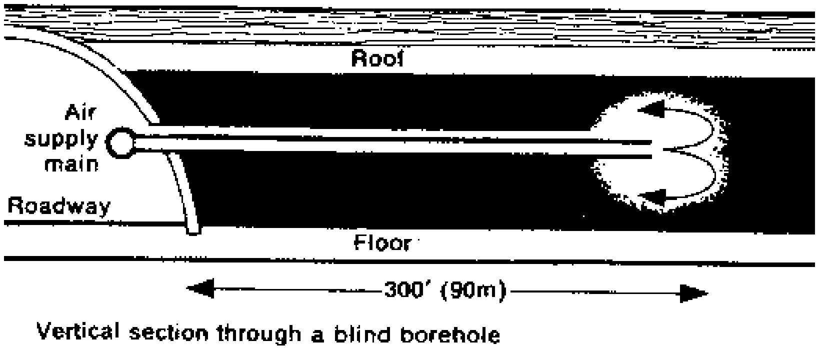
FSU - Vertical wells

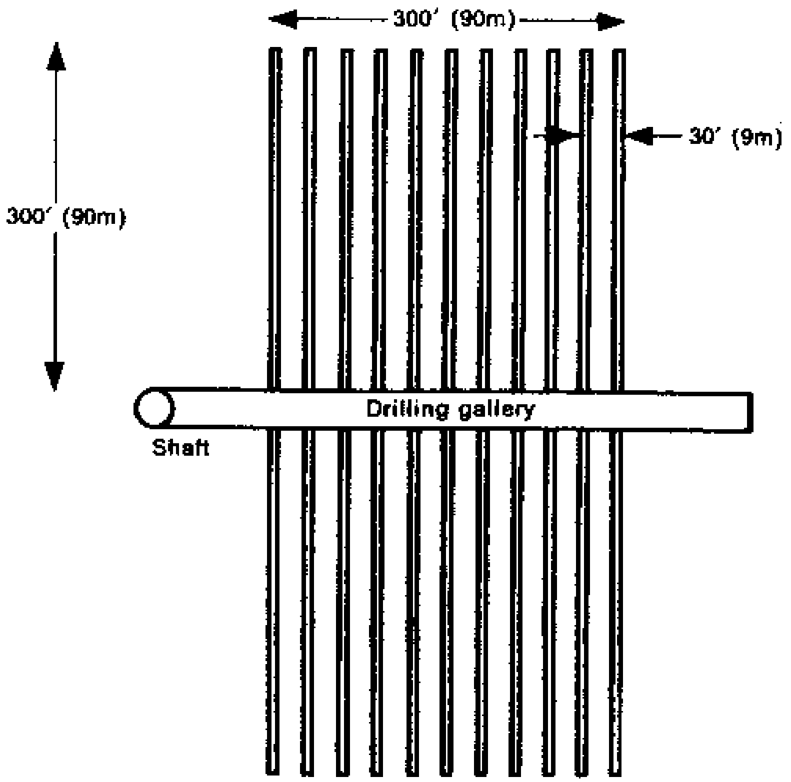


United Kingdom (UK)

- First UCG test was at Durham in 1912 and a full research programme ran from 1949-1959 to develop a commercial industry
- Commercial trials performed from 1956-1959 to develop a power generation site (unsuccessful, but the last trial performed well)
- Reviews in 1964 and 1976 to decide if research should be continued
- New research programme started in 1999

UK – Newman Spinney (1958)

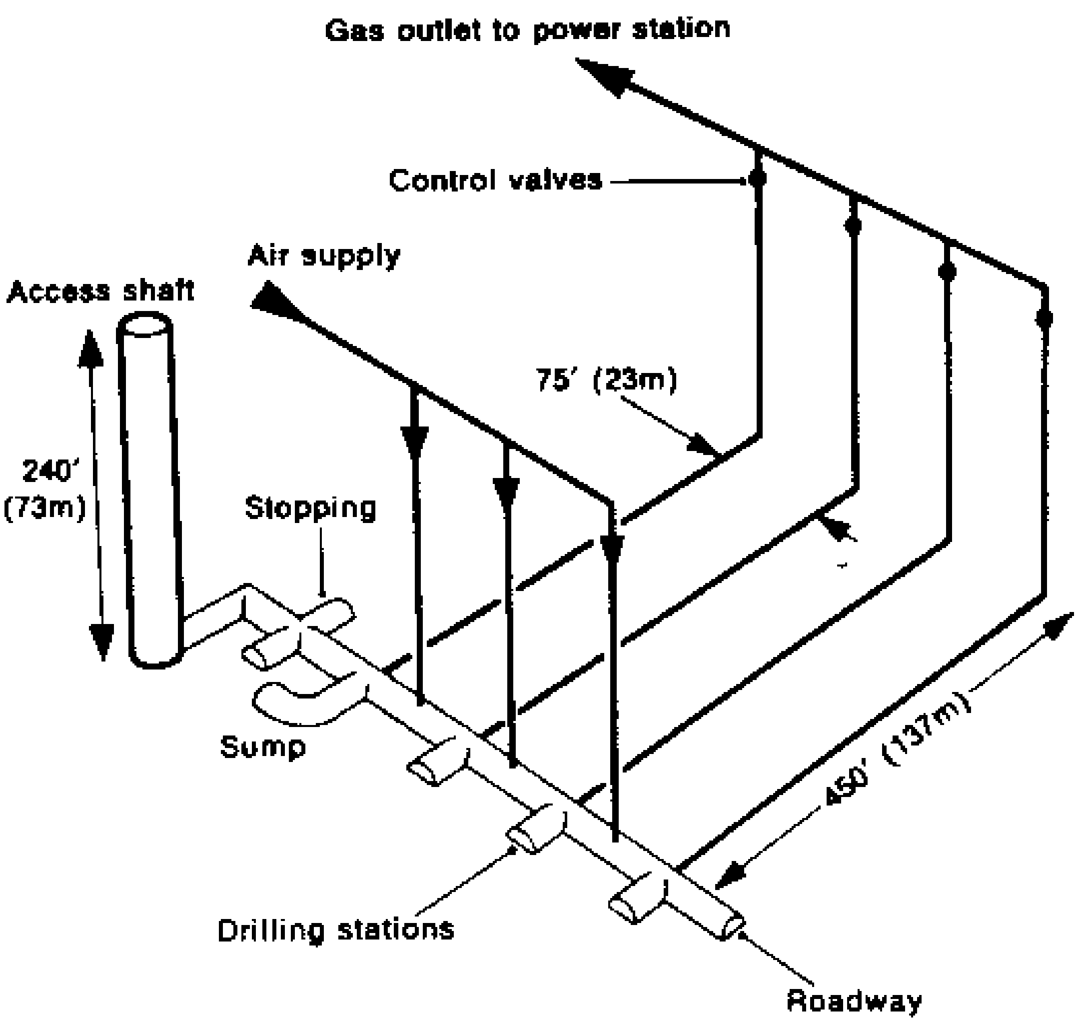


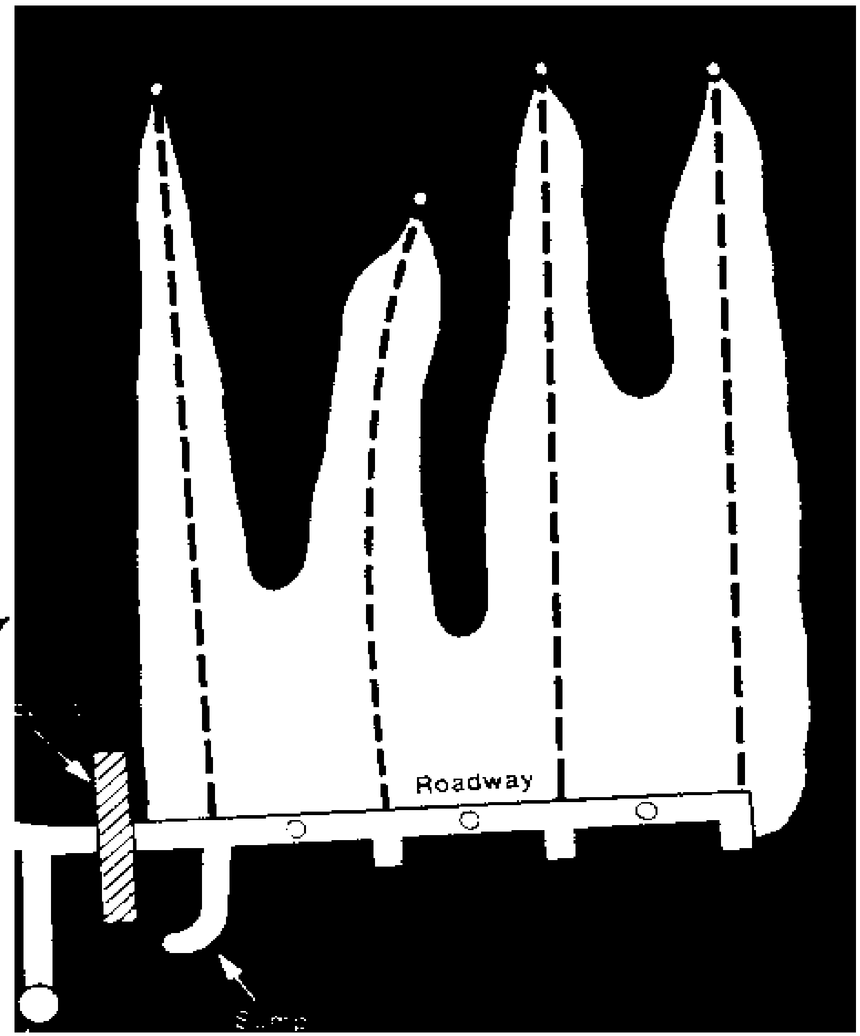


- **Blindhole layout gave the best performance during the experimental trials**
- **Problems were experienced with the injection pipes failing during operation**

UK – Newman Spinney (1958)

Final commercial design and cavity formed in trial





UK - Recent developments

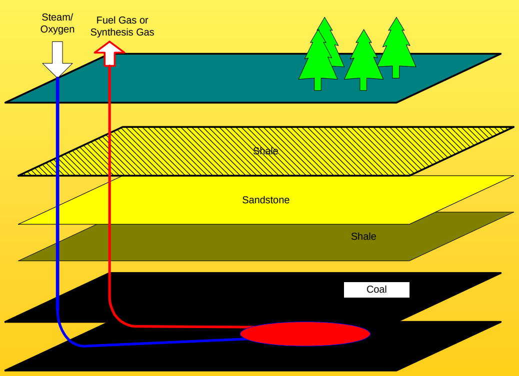
- New research programme commenced in 1999 to evaluate the potential of UCG to replace North Sea natural gas
- Most research has been on site selection, drilling technology, cost evaluation and environmental criteria
- Drilling and in-situ gasification trials have been delayed and now require industry support
- A feasibility analysis has been produced for a proposed site at the Firth of Forth

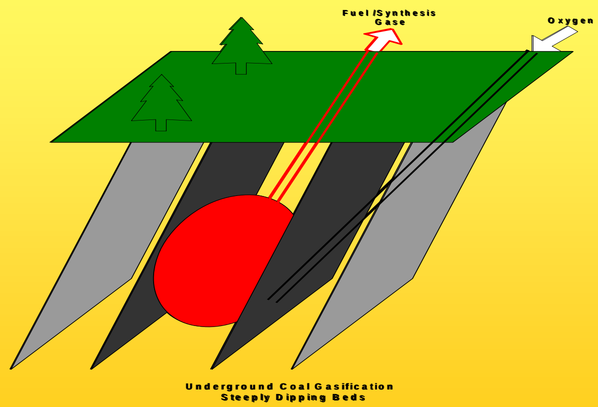
History of UCG in the U.S.A

By

Burl E. Davis

Carbon Energy Associate





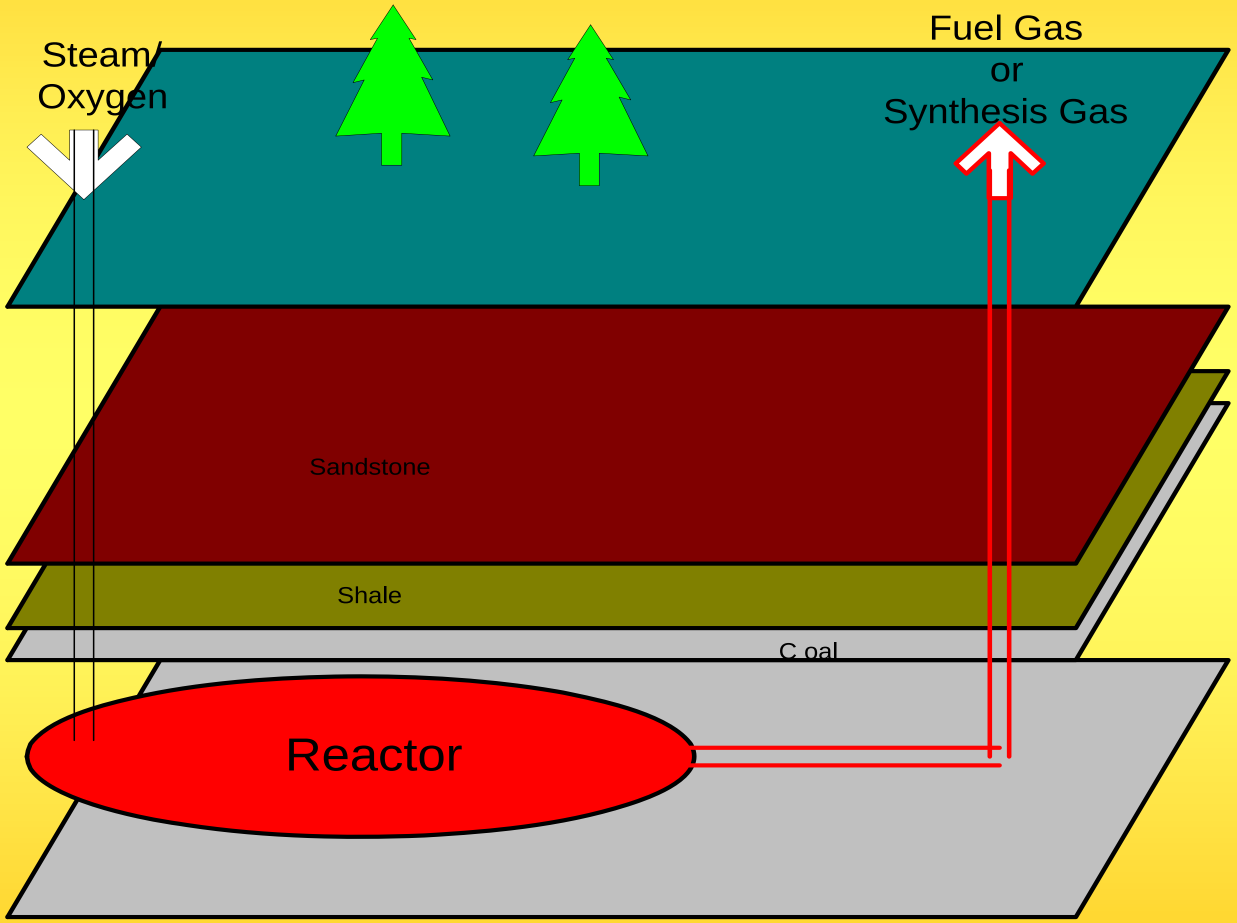
U.S. Department of Energy Programs

Date	Organ.	Location	Process Config.	Coal Rank	Seam Thick	Seam Depth
1971-1981	Laramie ETC	Hanna, Wy.	LVW-RCL	Sub.	7M`	80M
1972-1982	Lawrence Livermore	Hoe Creek.	LVW-RCL	Sub.	5M	30M
1977-1980	Morgantown	Pricetown WV	LVW-drilled link.	Bit.	3m	300m
1976-1982	Gulf /DOE	Rawlins	SDB	Sub.	7m	120-200m
1981-1985	Lawrence Livermore	Centralia, Wash.	CRIP	Sub.	6-8m	20-50m
1986-1993	Ind.Cons/DOE	Hanna, WY	LVW-CRIP	Sub.	7m	75m

U. S. Industrial UCG Projects

Date	Organization	Location	Proc. Config.	Coal Rank
1978-80	Texas A&M	Rockdale TX	LVW-RCL	Lignite
1976-80	Texas Utilities	Tennessee Colony	LVW	Lignite
1977-82	ARCO	Rocky Hill WY	LVW-RCL	Sub.

Linked Vertical Wells

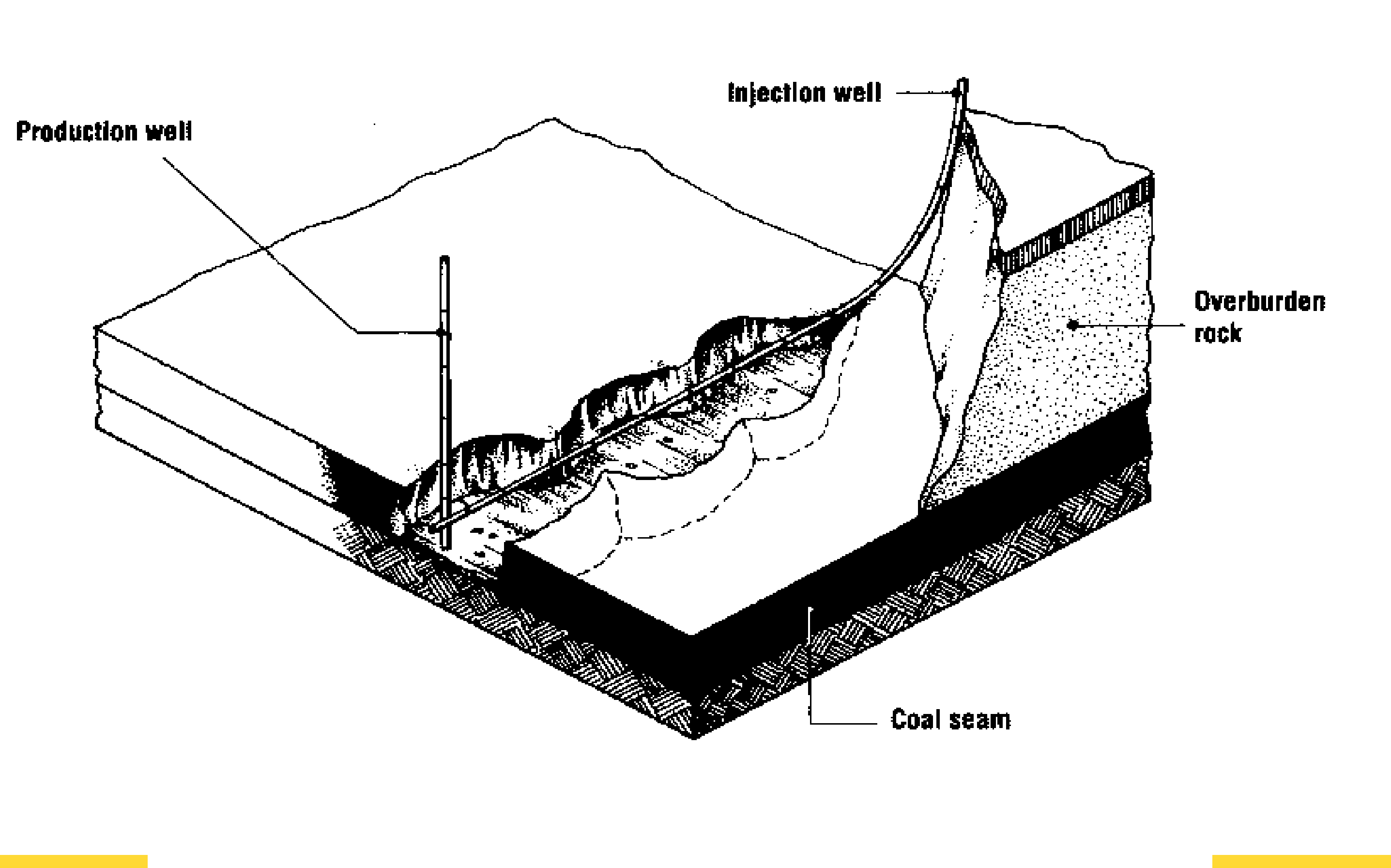


Hoe Creek Findings

Directional Drilling as the primary method of linking.

Importance of maintaining gas flow low in the seam.

Linear CRIP Configuration

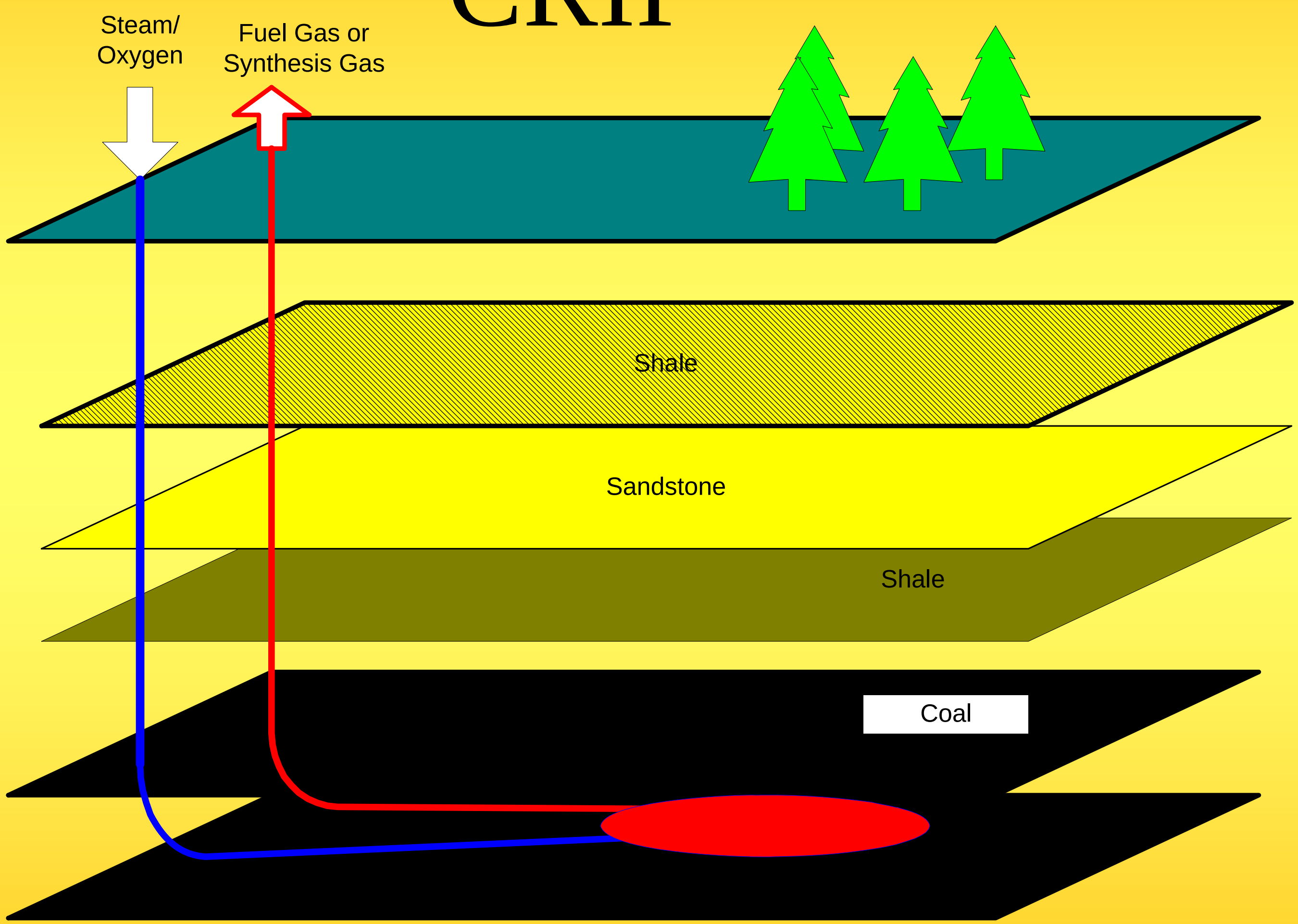


Rocky Mountain -1

Rocky Mountain 1

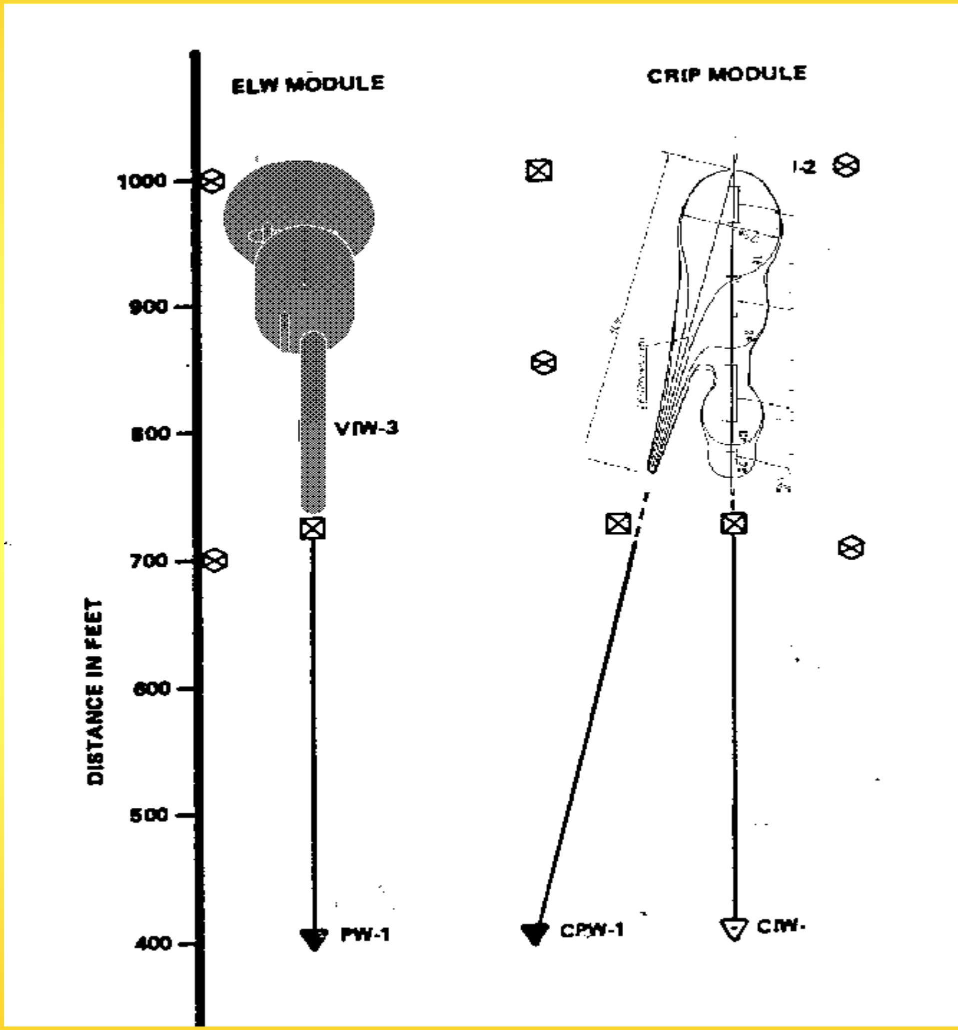
- Operation of parallel reactors
  - LVW
  - CRIP
- Steam/Oxygen
- Slip Stream Catalyst Test
- Full Environmental Compliance

CRIP



Steam/ Oxygen
Fuel Gas or Synthesis Gas
Shale
Sandstone
Shale
Coal

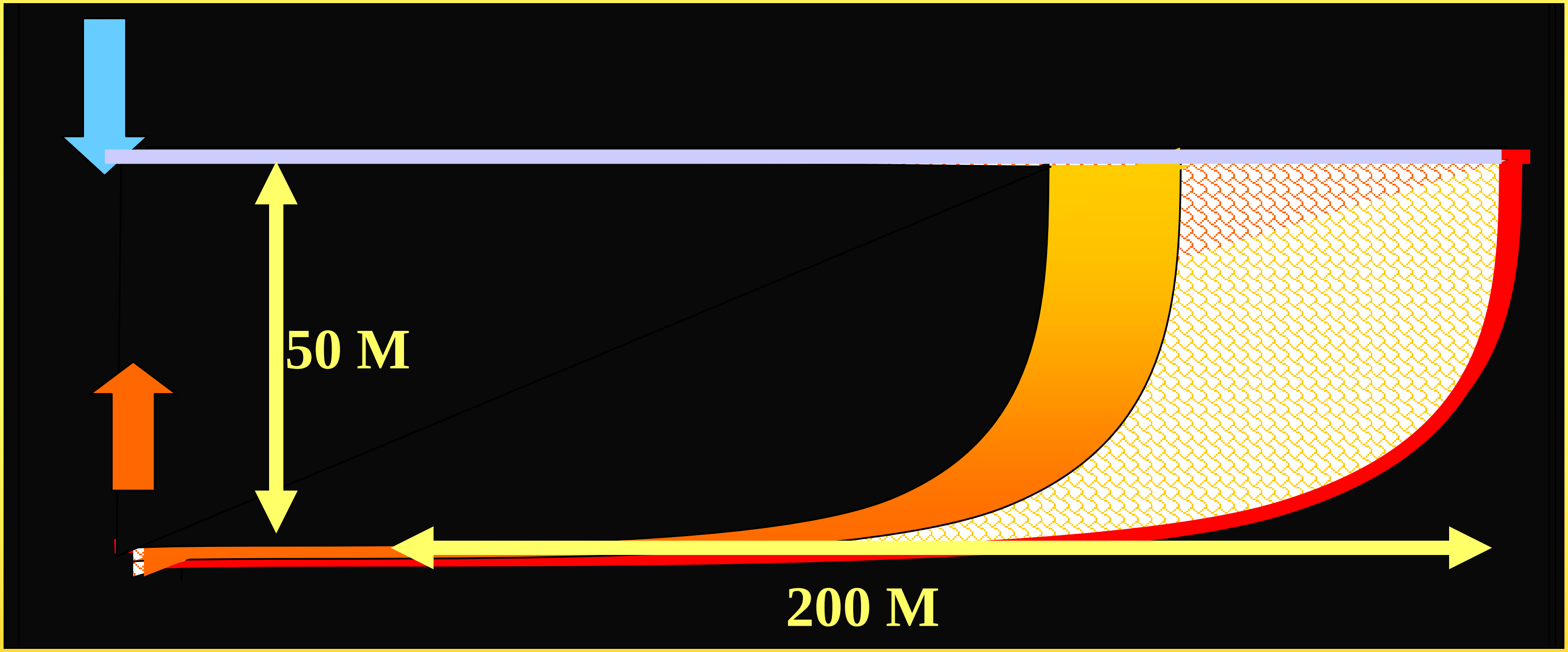
Rocky Mountain 1



Test Results

- **LVW**
  - **65 Days to Burnout**
  - **Second Injection Well**
  - **70-100 Tons/day**
  - **HHV 230-280 Btu/scf**
- **CRIP**
  - **90 Days of Operation**
  - **4 Reactors**
  - **70-200 Tons/day**
  - **HHV 250-320 Btu/scf**

CRIP Reactor Development
(Plan View)

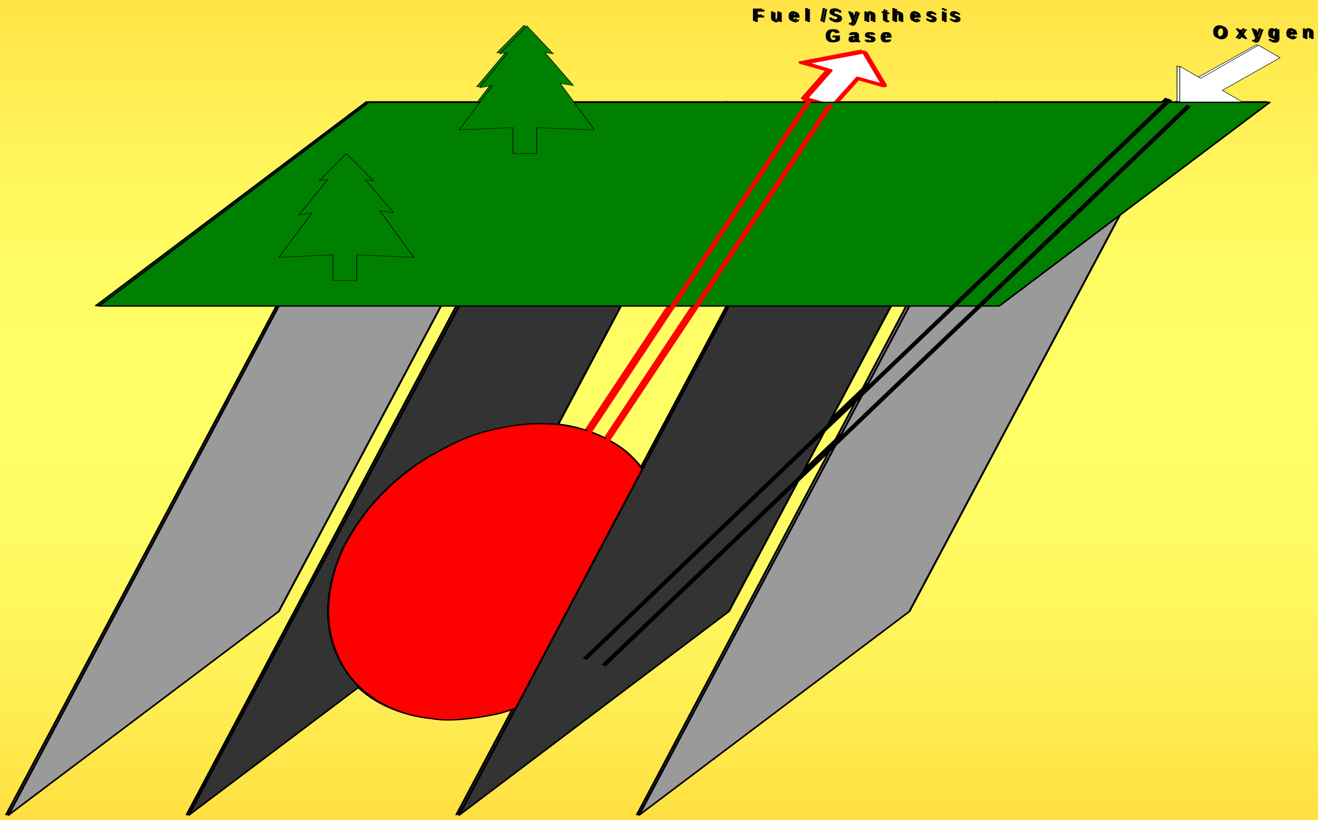


Rawlins

Rawlins

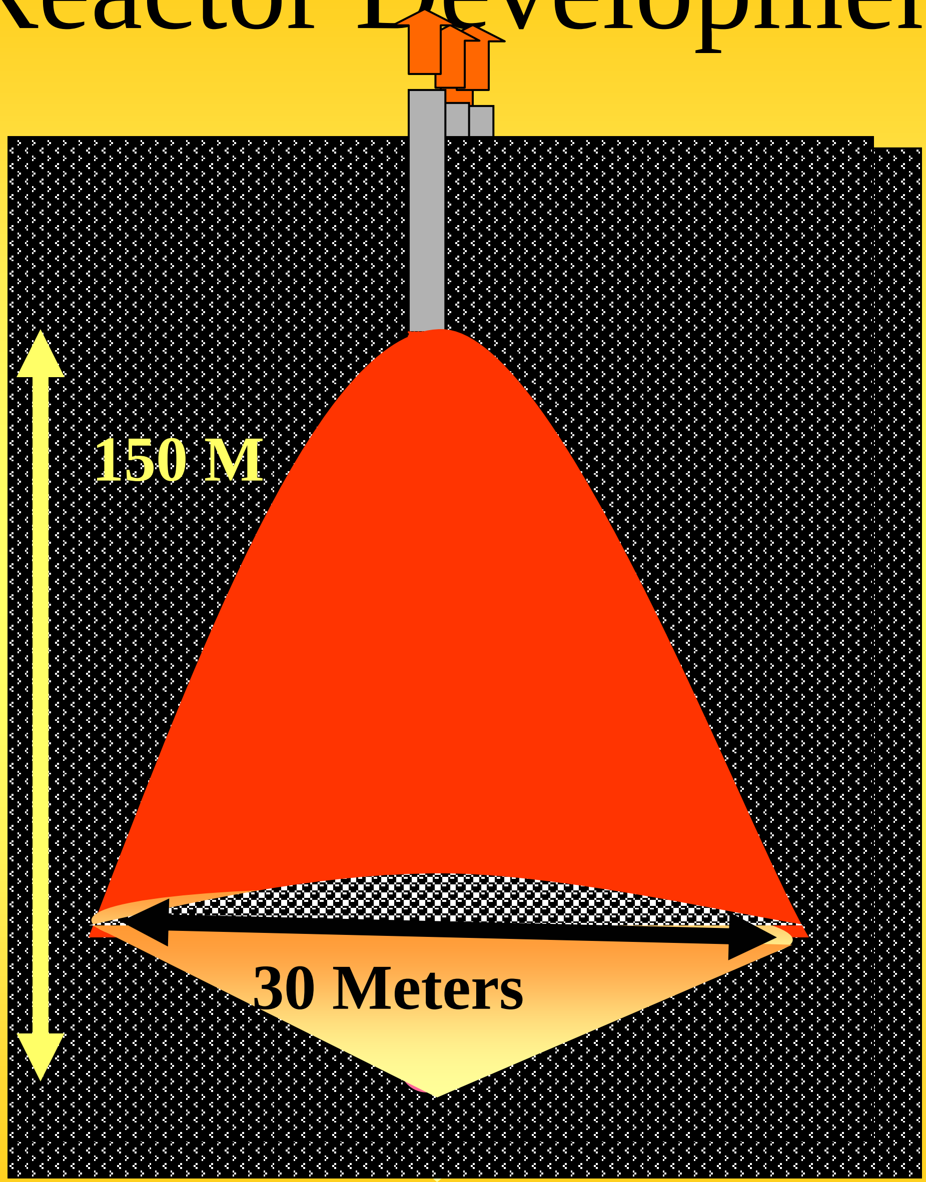
- Two Tests
- Gulf Oil Cost Shared Contract
- Subituminous Coal
- 7-8 Meters Thick
- Seam Dip 60º
- Full Environmental Compliance

Steeply Dipping



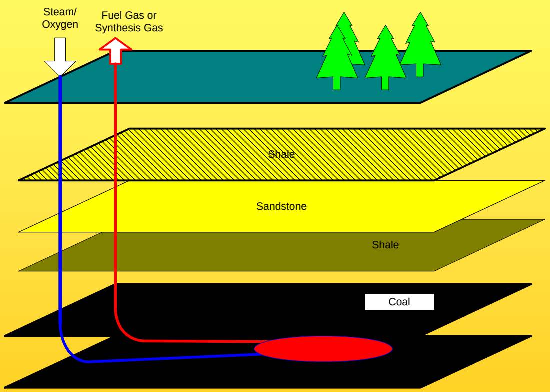
Underground Coal Gasification
Steeply Dipping Beds

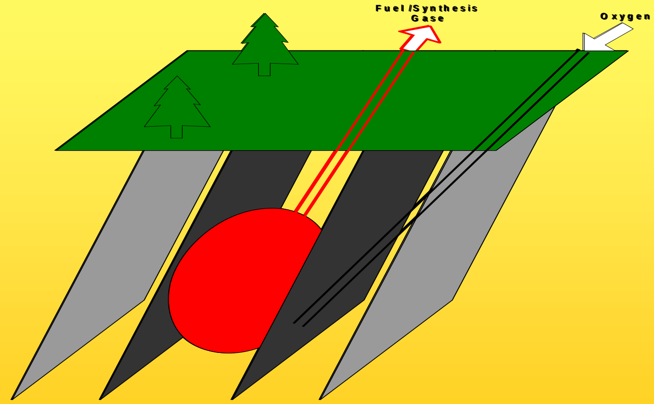
SDB Reactor Development



Horizontal vs. Dipping

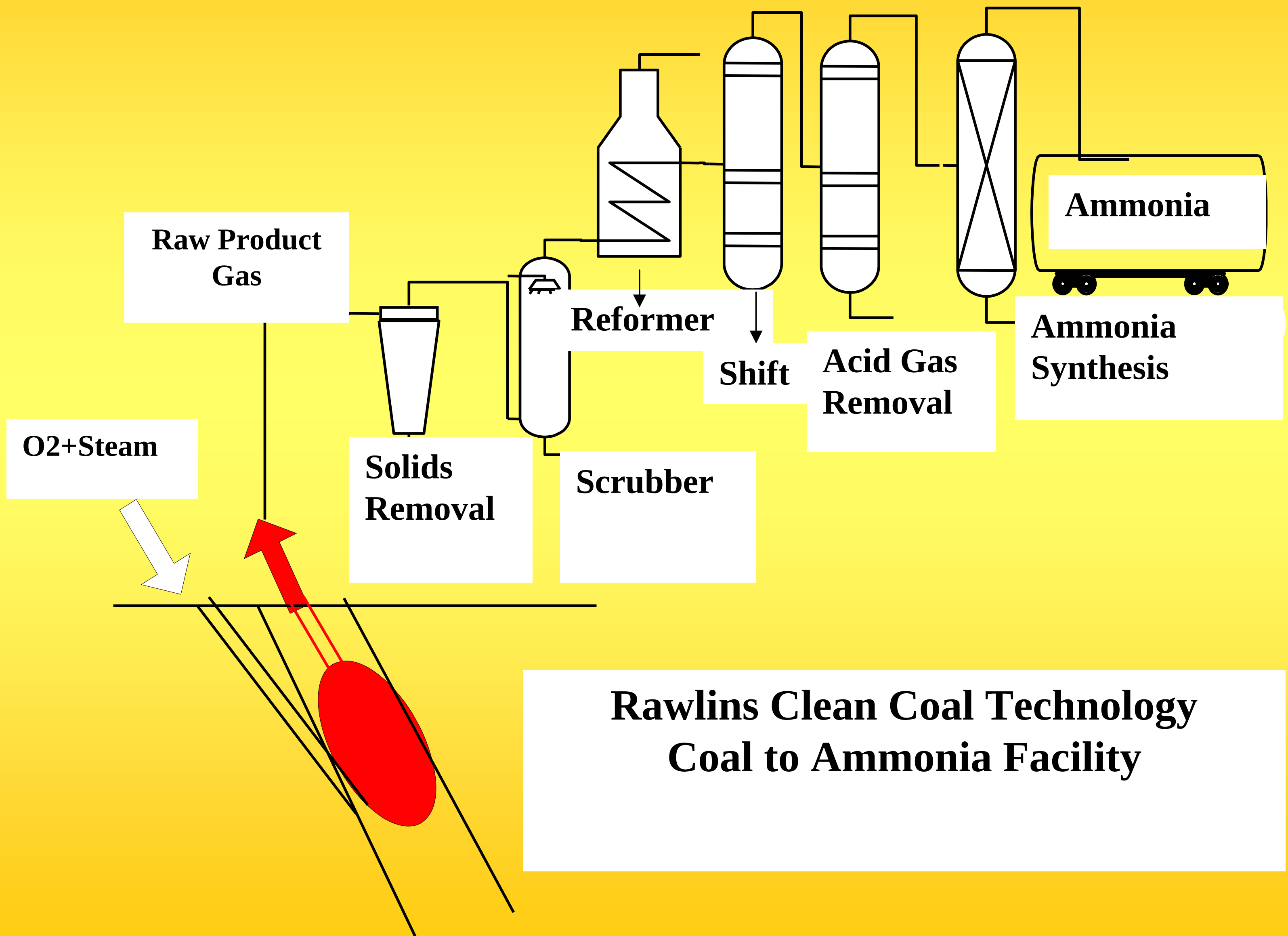
- Horizontal
  - Large Resource
  - 75-80% Thermal Efficiency
  - 0.4 O_2/1 coal
- Dipping
  - Limited Resource
  - 82-88% Thermal Efficiency
  - 0.2 O_2 /1 coal





Underground Coal Gasification
Steeply Dipping Beds

UCG to Ammonia



Rawlins Clean Coal Technology
Coal to Ammonia Facility

Conclusions

Each DOE UCG Program contributed to the evolution of UCG Technology

Results were published and available to other workers in the field

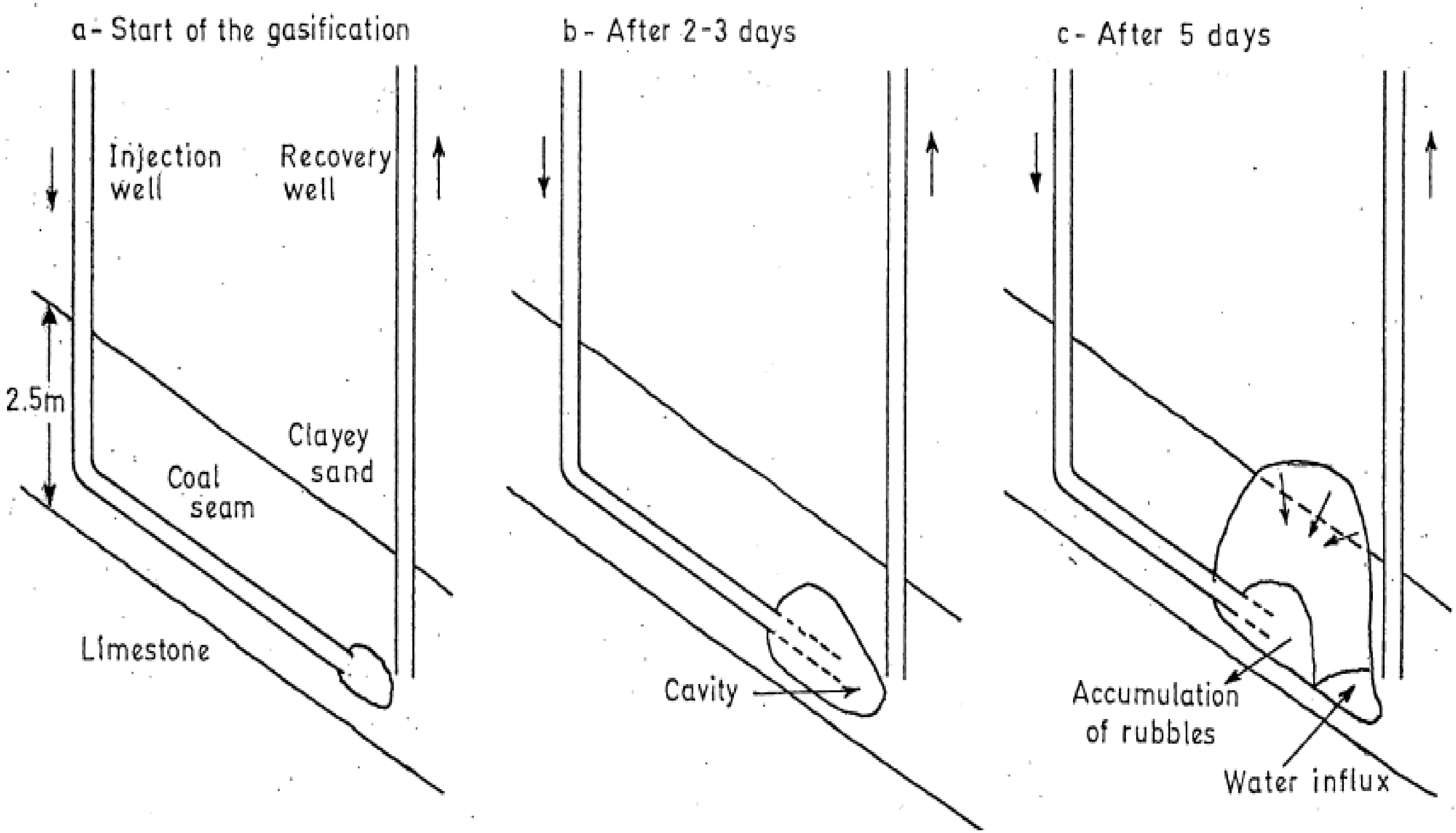
Virtually all of the technology is considered a the public domain

Europe

- **Experimental trials have been held intermittently since1948 in Western Europe in deep coals**
- **Recent notable trials have been at**
  - Thulin (1982-84 and 1985-86) in Belgium
  - Alcorisa (1997) in Spain
- **The recent trials have benefited from the use of CRIP technology as this is more suited to use in deep coal seams than vertical wells**

EU - Spanish Test Site

EU – Spanish CRIP progress



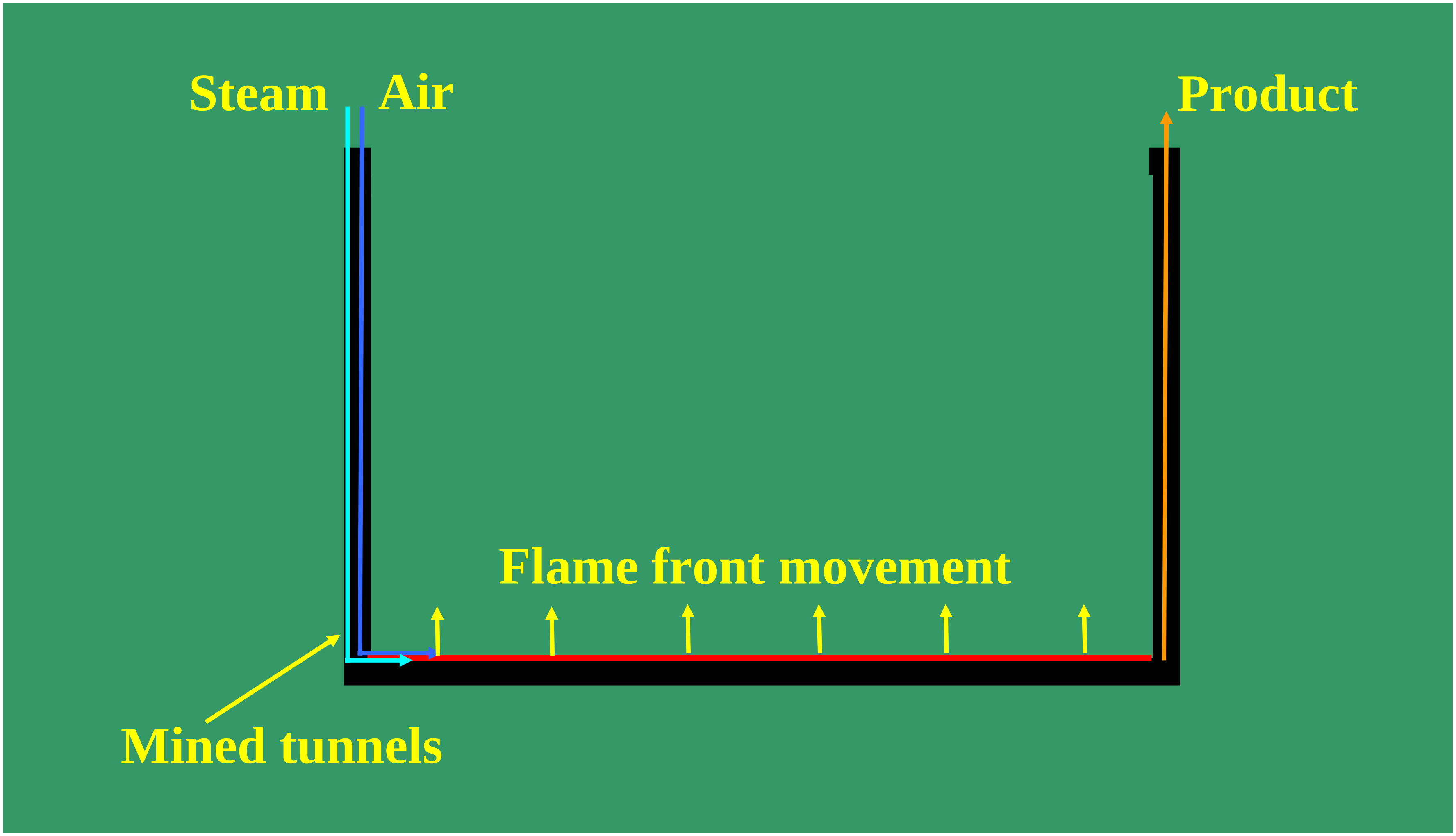
EU – Spanish summary

- **Coal seam ~2m thick at ~600m**
- **Oxygen and liquid water injection**
- **Operations hampered by high water production (wet sand overburden)**
- **Injection well failed structurally**
- **Construction and operation problems relating to poor site characterisation and selection**

China - Introduction

- China has developed a different technique using mined tunnels and has demonstrated it at least 12 sites since 1995
- Air and steam are used, sometimes in stages, to produce either fuel gas, synthesis gas or hydrogen
- While high quality gas can be produced using the technique, the economics are difficult to evaluate because most plants receive 5-year grants to aid construction and none have been expanded after the 5-year period

China – Tunnel technique



China – UCG usage

❖**Product gas from China's UCG sites has been used for various purposes, including:**

- Domestic fuel gas
- Coal-fired boilers
- Pottery kilns
- Ammonia synthesis

Australia – Linc Energy

CSIRO

CarbonEnergy

- Trial operated at Chinchilla from 1999 to 2002
- Over 30,000 tonnes of coal used in 2 gasifiers
- 10m thick seam at 130m depth using a modified vertical wells technique

Australia – Linc Energy

- **Linc Energy had a successful share offering earlier in 2006, raising $22million**
- **Development of a small liquid synthesis plant is planned at the same site as the earlier demonstration with the support of Syntroleum, a Fischer-Tropsch technology provider**

The End

- Dr Andrew Beath
- CSIRO Exploration & Mining

- Mr Burl Davis
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- USA