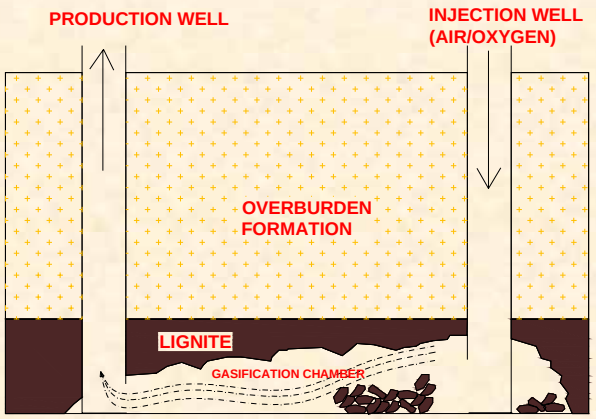
Underground Coal Gasification (UCG) power generation

Drilling in an Indian Mine Location - Consortium

What is UCG?

- UCG is the in-situ physico-chemical process of conversion of un mine-able (deep seated, less thick seam, steep dipping) coal / lignite into a combustible product gas (fuel gas)
- The product gas is a mixture of hydrogen, carbon monoxide, methane, carbon dioxide & higher hydrocarbons.
- Calorific value of product gas is in the range of 700 to 1200KCal/NM^3 for gasification with air injection

UCG Process



UCG operation is initiated by drilling two adjacent boreholes into the coal seam and injecting pressurised oxidants like hot air, oxygen or steam into the coal seam, igniting the coal seam and recovering the combustion gasses through the adjacent borehole. The connectivity between the injection and producer wells are made by special linking techniques.

UCG COMMERCIALISATION

❖CONCLUSION

- ✓ UCG gas production process is ready for commercialization

❖EVIDENCE

- ✓Very long history of coal gas production and use
- ✓ Long history of UCG gas production and use
- ✓ Proven technology for UCG gas production and use
- ✓ Perceived barriers to development overcome
- ✓ Current commercial potential is high

COAL GAS HISTORY

- ✓1802 - First street lights in UK using coal gas
- ✓1812 - First gas works in UK
- ✓1820s- First coal gas light in Sydney
- ✓1862 - Hong Kong & China Gas Co. formed
- ✓1870s- Gas cooking introduced to Australia
- ✓1965-1975 Natural gas replaces coal gas in Australia
- ✓2002 - Hong Kong and China Gas Co produces and distributes 9 million cu.m. gas per day through 2800 km of pipe
- ✓2002 - IGCC plants start operating in many countries

UCG GAS HISTORY

- FSU - Over 15 million tonne coal gasified since 1950s
- USA - 50,000 tonne coal gasified since 1970s
- Europe - Less than 10,000 tonne coal gasified
- Australia - Over 32,000 tonne coal gasified 2000–2002
- India –1980's trials

TECHNOLOGY FOR COMMERCIAL USE

- Gas Production - more than 70 years of gas production and pilot test work
- Gas Clean-up – filter systems developed for IGCC plants in US and Europe
- Power Generation - low BTU combustors developed for turbines in IGCC plants

COMMERCIAL ISSUES TO OVERCOME

- **No access to FSU experience /recent trials in US/Australia/China & Europe**
  - ***-- Few responses to BHEL recd from UK/UCG Engg & others***
- **Concerns for environmental issues**
  - ***--Satisfied by monitoring evidence***
- **Range of technical disciplines involved**
  - ***--Personnel from -ISM/Dhanbad & CMRI & MECL with reqd experience***
- **Focus on Govt.-funded R&D**
  - ***-- Provide Govt. support to industry UCG projects***
- **Perceived high cost of production**
  - ***-- Examples like Chinchilla plant cost /design need to be worked for Indian situation***
- **Negotiate financing package**

♣The process involves:

♣ Drilling of two adjacent boreholes into coal seams (>100 m deep)-one serving as injection well while the other as production well.

♣ Formation of linkage between the boreholes

♣ Down hole ignition of coal seams.

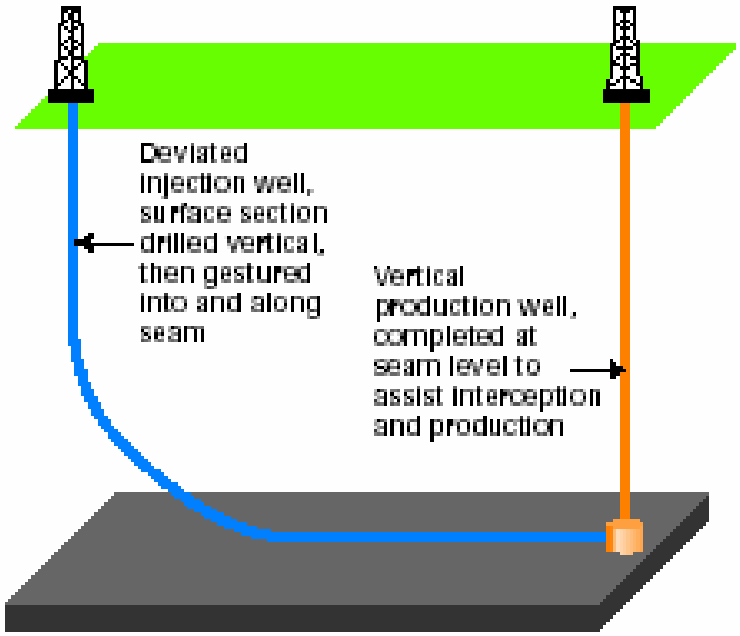
♣ An underground gasifier is made up of a number of underground reactors with largely independent outputs. The gas streams from different reactors can be mixed as required to ensure consistency of overall gas quality. The outputs of reactors can be varied in order to optimize coal extraction and gas supply from the whole gasifier.

♣ Ground water influx into the gasifier creates an effective "steam jacket" around the reactor making the heat loss in situ tolerably small.

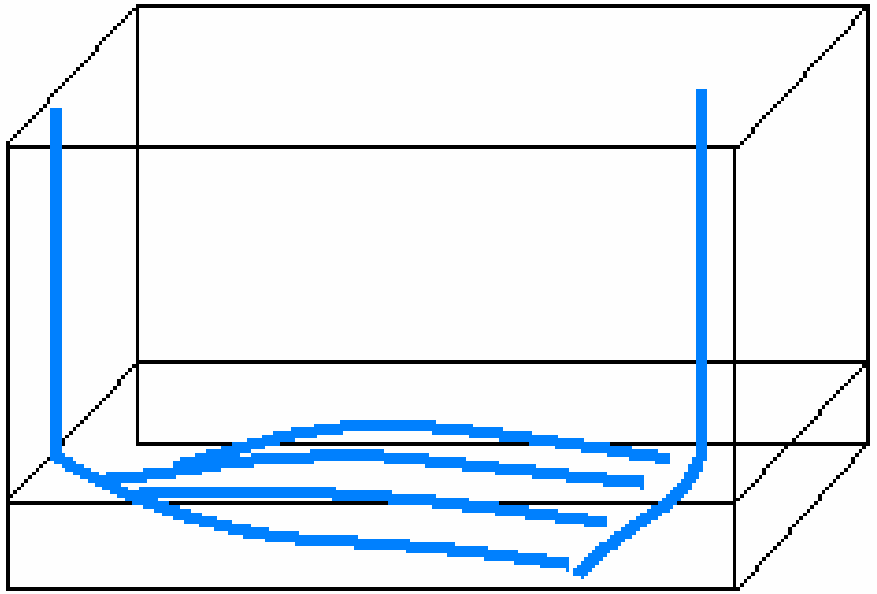
♣ Optimal pressure in the underground gasifier promotes ground water flow into the cavity, thus confining the chemical process to the limits of the gasifier and preventing contamination in the area.

♣ Product gases are recovered from second hole. Drilling and connecting additional injection and production wells can readily expand the initial gasification reaction.

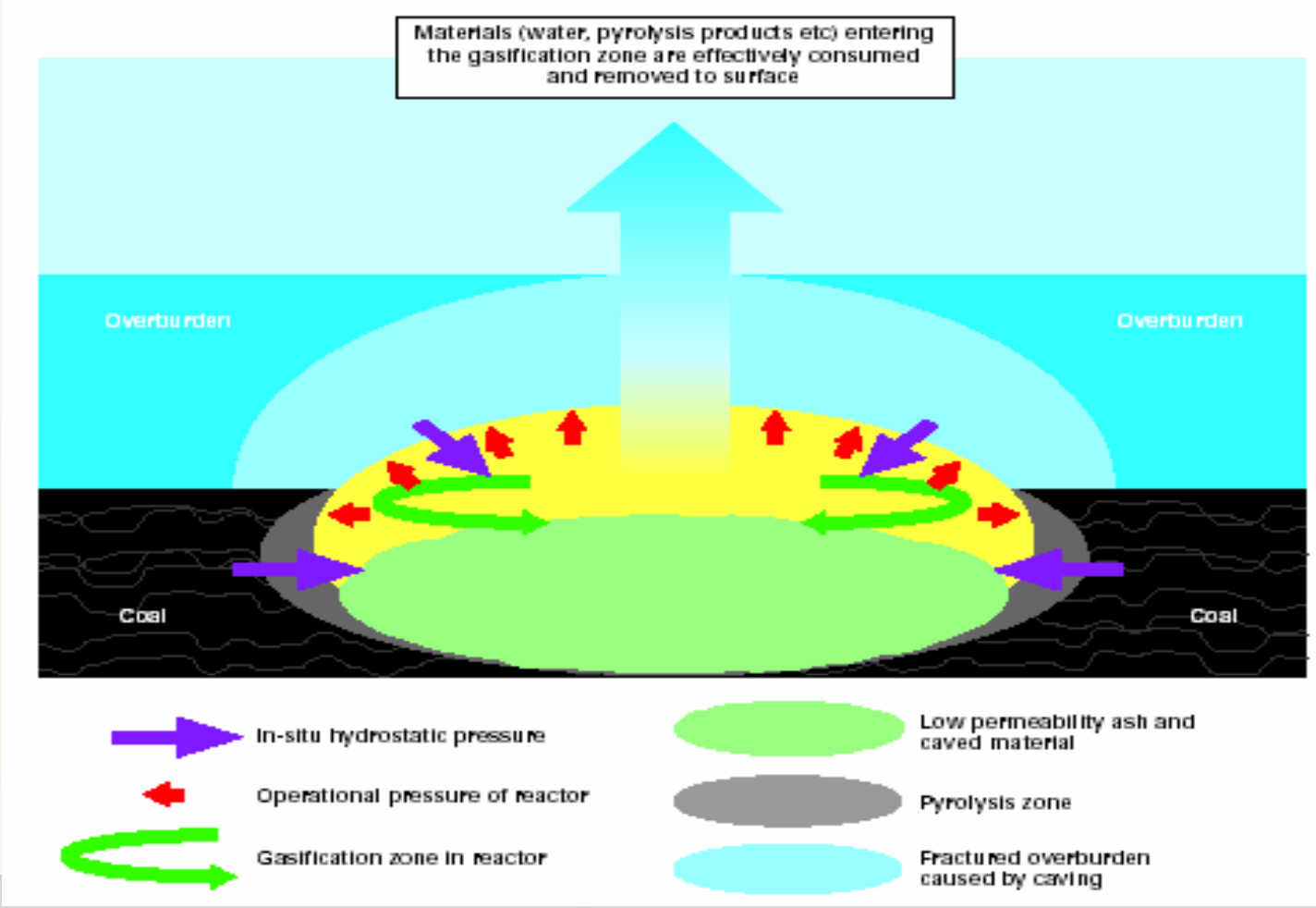
Basic UCG module configuration



UCG configuration branching and intersections



Underground pressure conditions and Bubble during UCG



Why UCG?

Typically, coals of low rank e.g. lignite and sub-bituminous are the easiest to gasify, hence better suited for UCG. Underground Coal Gasification offers a potential means of extracting energy from deposits, which will not be amenable to conventional mining, economically.

India is endowed with vast lignite resources of around 36 billion Tonnes. A major portion of these resources occur at relatively deeper depths or constrained by one or more factors for commercial mining.

In view of the above, a non-conventional technology such as UCG has opened up new avenues for harnessing the vast potential of these resources, thus enhancing the energy security of the country.

UCG Potential In India

- The country has very large deposits of deep seated coal and lignite which are not amenable to extraction by conventional mining methods.
- The present coal reserve is 2,53,359 million tonnes as on 1st January 2006 (GSI data). Recoverable reserve has been estimated as 95, 866 million tonnes, only 37.8%.
- Lignite resource of the country is 37,154 million tonnes as on 1st April 2005 (GSI data). Recoverable reserve has been estimated as 4, 260 million tonnes, only 11.5%.

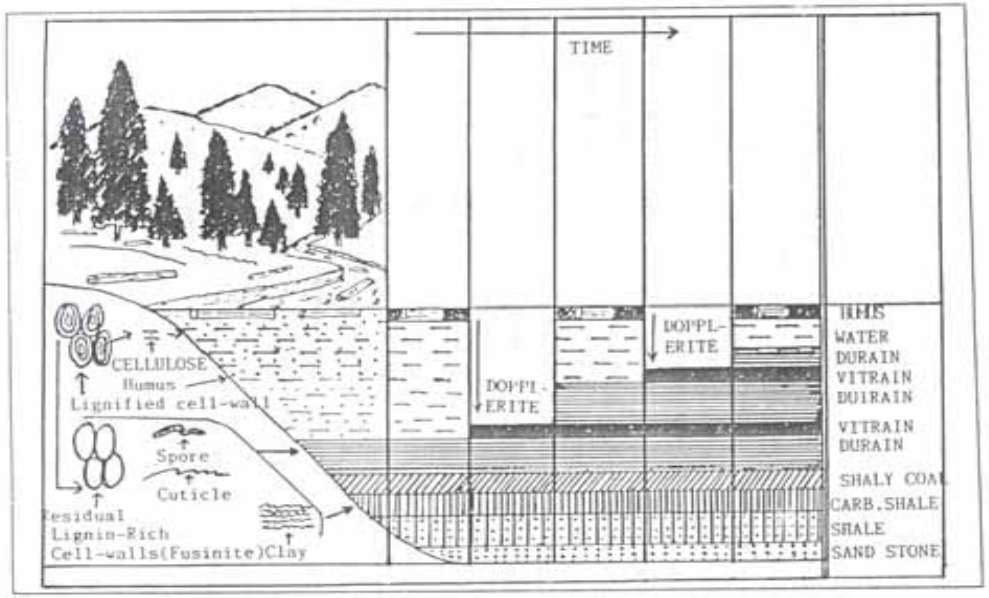
Coal Reserves & UCG Power Capacity

For capacity	**: 250/300MW**
For Service Life	**: 30 to 35 Years**
Reserve Required	
With Coal (Tonnes)	**: 30 to 40 Million**
Lignite (Tonnes)	**: 50 to 60 Million**

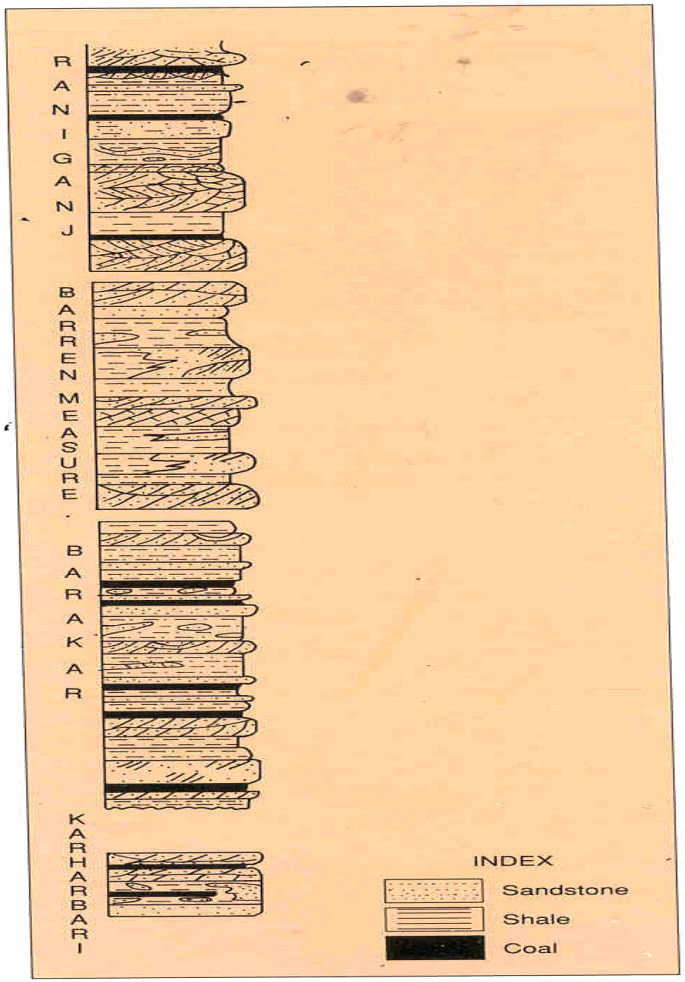
Overview of Indian Coals

Organic Aspects

- Sedimentation and Drift Origin
- Most of them Sub-Bituminous in Rank (78%)
- Coals are generally very reactive
- Both Thick and Thin seams are prevalent



Schematic diagram showing development of typical coal seam with characteristic lithotypes arranged in a banded sequence- sand stone, shale, carbonaceous shale, shaly coal and coal



Typical Stratigraphic Sections of Karharbari, Barakar & Raniganj coal Measures

Overview of Indian Coals

Inorganic Aspects

- Minerals homogenously mixed with coal
- Due to Sedimentation Deposition, Floor of coal Seam contains Sandstone, Shale & Carbonaceous Shale and Shaly coal
- Similarly there is transition from Prime coal to overburden layers
- Mineral Matter in core Coal Seam is much less (20 to 30%) Mineral Matter content goes up from Core towards Overburden and Floor(40 to 60%).

Lignites of India

- Lignite's of Fresh Water Origin
- Tamil Nadu, Pondicherry (Offshore also), J&K., Kerala
- Lignite's of Marine Water Origin
- Gujarat : Lignite Reserves considered Equivalent to Total Indian Coal Reserves, but at a depth of 1000 meters & above(Mehsana – Ahmedabad Block & Tonsan Block -Patan – Tharad).
- Rajasthan: More locations, each with less quantum of reserves (100-400 meters depth. Ash content varies widely)

UCG Past Activities in India

- In India, UCG was taken up as a National Project in early 80's.
- A protocol was signed between India and erstwhile USSR in 1981 for assistance in the field of UCG.
- A multi agency core group was formed.
- An S&T project on underground coal gasification was taken up by CMPDI with technical support from USSR.
- ONGC drilled two wells during 1984-86 to study in deep lying lignito-bituminous coal of Mehsana, Gujrat. Further study on this subject has not been made since then.

UCG Activities in India

UCG S&T Project

- Soviet experts found coal of South Sayal, Medni Rai and Merta Road lignite deposits as suitable for further evaluation after studying preliminary data
- Additional data were generated in the identified blocks.
- Medni Rai was found unsuitable in view of complex hydro-geological regime.
- South Sayal and Merta road were found technologically feasible & Soviets opined that techno-economics could be worked out only after Pilot Plant studies.
- Pilot appraisal could not be taken up due to apprehension of contamination of ground water.

Consortium Approach

- Consortium Members
- BHEL (leader- Build)
- SCCL (own & operate)
- CMRI
- ISM

Present Status of Consortium

- MOU -ready for Management Approvals
- Technology / Overseas Consultant –Responses recd
- Understanding- Discussions one round with SCCL & BHEL and BHEL & CMRI completed

BHEL's Experience with Indian Coals & Power Generation

- Has utilised many types of Coals & Lignite
- Employed different Combustion Technologies
  - Pulverized coal, Fluid Bed & CFBC
- Employed Different Gasification Technologies
  - Atmospheric and Pressurized Moving Bed
  - Pressurized Fluid Bed (6.2 MW CCDP)
- Characterized Organics & Inorganics from Combustion, Gasification & Emission (Sulphur, Trace metals) View Points.
- Designed, built and operated the only IGCC plant with high ash Indian coal

IGCC – 6.2 MW Combined Cycle Demo Plant of BHEL

- Unique facility configured to study, develop and optimize various aspects, concerning the design, operation, maintenance, scale up of Integrated Coal Gasification Combined Cycle Power Generation Technology

Equipment Required for UCG

Upstream Equipment

- Compressors (Air & Nitrogen)
- High Pressure Water Pumps
- Drilling rigs

Gasification Equipment

- Air & Steam Mixing Vessel
- Seamless Steel Tubes and Valves
- Ignitors

Downstream Equipment

- Dust Cyclones: Due to high ash content, dust loading in Fuel Gas could be high
- Gas Coolers
- Scrubbers
- Electro De-tarring

BHEL is capable of supplying the above equipment

BHEL Centrifugal Compressors

- FLOW : UPTO 350000 NM^3/HR
- MCL Model
  - Horizontally Split Casing
  - Discharge Pressure – Up to 40 Kg/Cm^2
  - Services – Air / Ammonia, Propylene, Wet Gas
- BCL Model
  - Vertically Split Casing
  - Discharge Pressure – Up to 350 Kg/Cm^2
  - Services – Syn Gas / Hydrogen / Natural Gas

BHEL Drilling rigs

- **Onshore Rigs for drilling up to a depth range of 1500 m to 9000 m**

Equipment Reqd for Power Generation System

- Gas Turbine: BHEL makes 4 to 250 MW capacity
- HRSG to suit GT
- Steam Turbine to match HRSG
- Burning of UCG gas in Boilers(directly for combustion after purification)

- BHEL is capable of system engineering and supplying the above equipment

Combined Cycle Plant of BHEL

Other Equipment required for UCG

- ✓**Steel Stacks**
- ✓**Structures for Injection & Production Wells**
- ✓**Piping Systems**
- ✓**Motors, C&I etc.**

✓ BHEL is capable of supplying the above equipment

Dynamics of UCG-IGCC Operation

- Process parameters viz Pressure, Outlet-temperature & Flow of Fuel gas is governed by coal and rock properties, which vary with time and location.
- As gasification progresses, process conditions need to be monitored continuously.
- Process parameters have to be adjusted to accommodate ever-varying gasification conditions.

Simulation & modeling experience of BHEL can be leveraged.

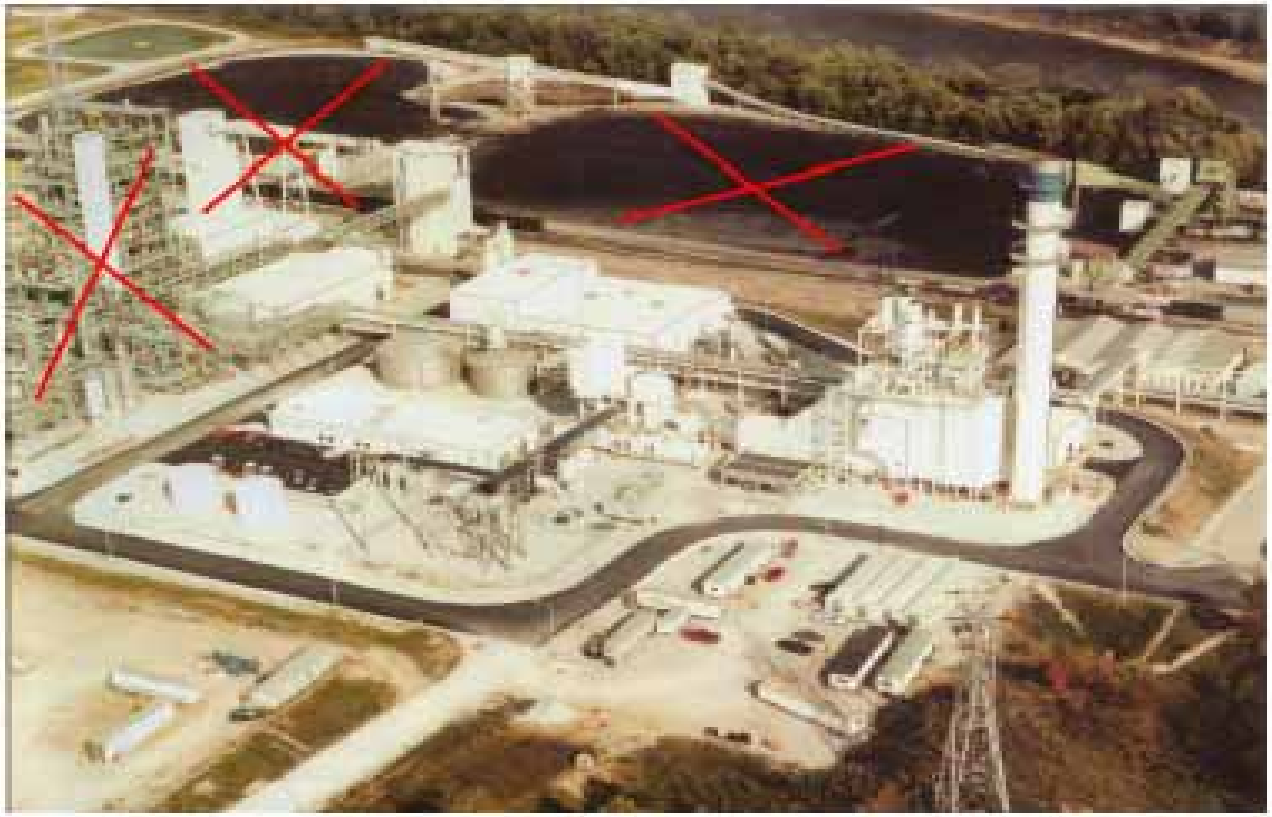
ISM/ Dhanbad's Simulation & modeling experience will be used

Most of the equipments reqd for UCG…..

- BHEL has very Good Experience in Product and System Engineering, Manufacturing & Operation of High Pressure Gasifiers and Combined Cycle Power Generation, most of which is akin to and relevant for UCG & UCG Based Power Generation
- BHEL is committed to participate & develop UCG Technology in India by making available, necessary equipment for Gasification & Gas Utilization for Power Generation.

UCG advantage over Surface IGCC

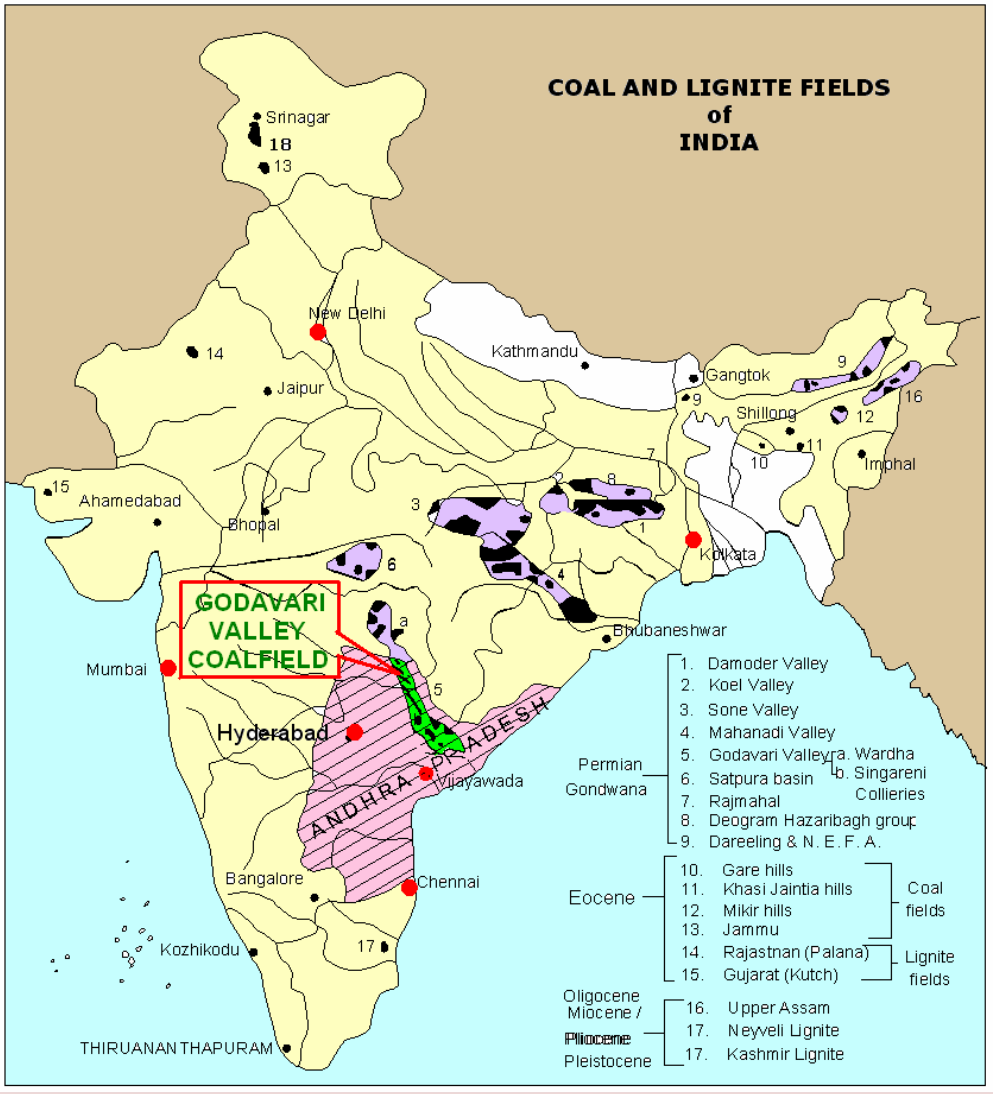
- ✓No Gasifier
- ✓No Coal
  - -Supply ,
  - -Transport ,
  - -Storage
  - -Preparation
- ✓No Ash and Slag

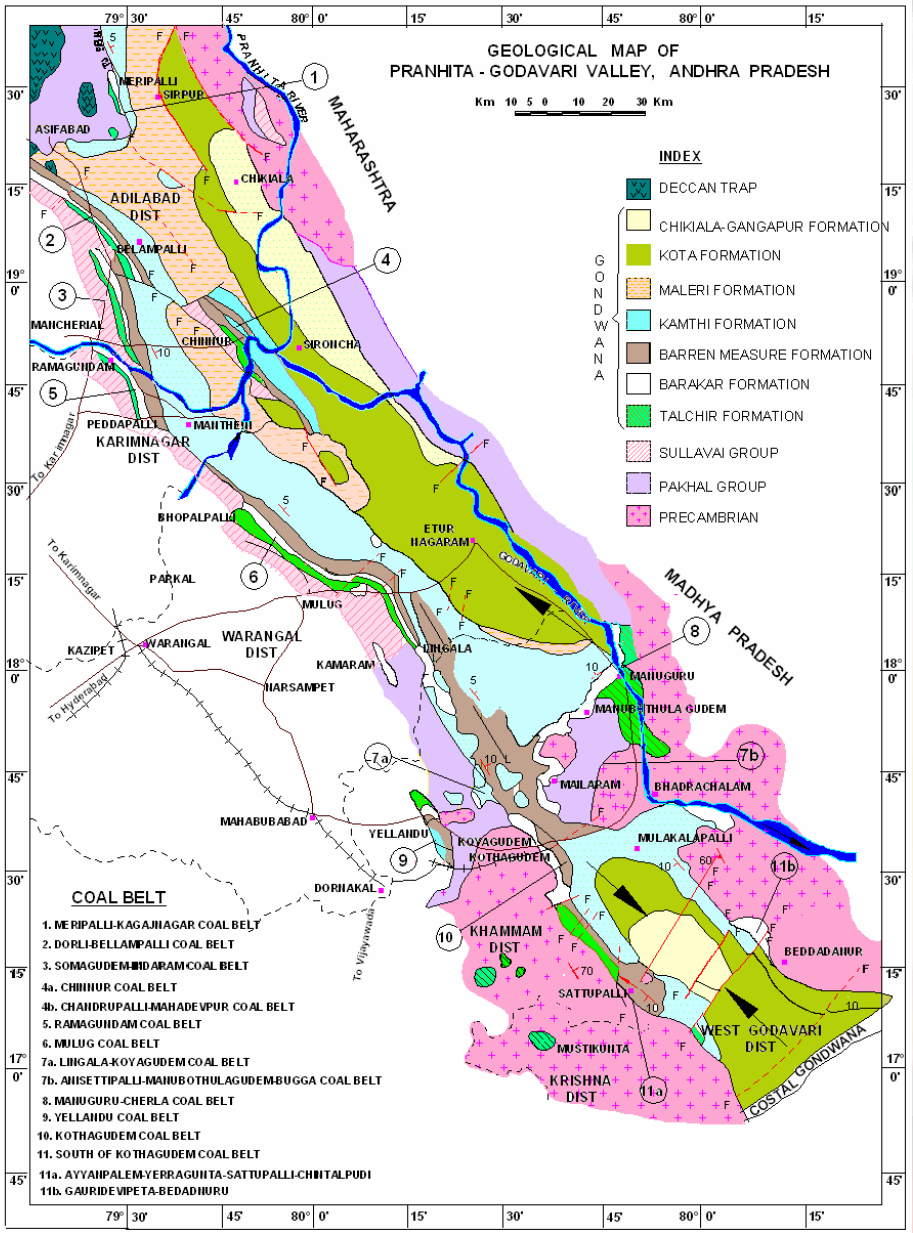


Strengths of M/s SCCL (Owner & operator)

- SCCL is engaged in exploration, winning and marketing of coal, possesses vast and proven expertise and resources in the field of exploration and mining coal.
- SCCL have suitable coal blocks for conducting the UCG trials leading to possible steady Gas production.
- SCCL had conducted numerous borehole drills and sufficient data bank exists on Geological & Hydrological data
- SCCL has the capability in generation of additional data if so required for under ground coal gasification.
- SCCL finalizing tie up with Australian Technology partner

Godavari Coal Fields in India





SCCL Command Area Mines Detailed Map

Strengths of CMRI & ISM/Dhanbad

- Central Mining Research Inst –*CMRI* had already carried out, preliminary studies on UCG and has know how for assessment of sites. CMRI will monitor the drilling agencies and take care of EIA / EMP activities.
- Indian School of Mines –ISM /Dhanbad have Modelling capabilities for UCG
- ISM/CMRI combine will be in charge for engineering work including modeling below the Ground for UCG Trials ..,

Know-how / Know-Why areas for UCG

- Exploration
- Drilling
- Operation
- Surface Installation
- Safety Requirements
- End Use
- Environment Impact Assessment

1.Exploration

- Field Mapping
  - Coal Seams,Overburden,Floor,Intermediate shale, DIP
- Coring
  - Ideal Hole Size,,Coring of Strata upto Floor, Aquifer Pressure
- Laboratory Studies
  - Porosity ,Permeability,& Compressibility of Total Strata(at Half Meter interval), and Gasification reactivity of Coal
- Fault Structure of Local Strata
- 3D Seismic Survey& Modeling of Hydro-Geology,

2. Drilling

- ✓ Configuration & Well Completion
- ✓ Details of Injection & Production Wells (Casing Size&Type,Tubing Size & Type, Cementation Requirements/Specs)
- ✓ Estimation of Normal distance
- ✓ Between Injection & Production Wells, Geological Aspects Deciding the distances

3. Operation

- Estimation of Air / Oxygen Parameters
- Cost Economics of Air Vs Oxygen
- Types Of Igniters & Chemicals
- Estimation of Permeability Requirements& Techniques to create Permeability (Directional in seam Drilling with Retractable Injection (CRIP), Reverse Combustion, Hydro Fracturing /Fluid)
- Techniques to Maintain Permeability for Gas
- Estimation of Gasification temperature

Some R & D Requirements for operation

- ✓ Effect of Injection Pressure & Quality of Air /Oxygen and Water Seepage, on Quality of Gas Produced (Composition, CV etc)
- ✓ Simulation Test Facility Construction Studies
- ✓ Continuous monitoring of Cavity Performance (Quality & Quantity)
- ✓ Computational Fluid Dynamic Studies

Controls and Instrumentation

- Sensing of Coal Boundaries from Down-hole Drilling Assemblies
- Telemetry to Surface
- Active Devices to Control the Intersection of Wells with in the Coal Seam

4. Surface Installations

- Type of Christmas Tree Valve Separators for each production wells
- Lay out of Compressed Air / Water Lines w.r.to Injection wells
- Lay out of Coal Gas Lines from all Production Wells to Gas Clean Up Systems & Utility Island
- Flaring System Design
- Moisture, Light Oil & Tar (Electro Detarrer) Gas Clean Up and Oil /Tar Handling & Storage

5. Safety Requirements

- Snuffers
- Fire Arrestors
- Fire Fighting Equipment
- Surge Arrestors
- Explosion hazard modeling
- Purging system

6. End Use View Points

- Power Generation
  IGCC,
  UCG with IGCC.
  UCG to PC Fired Boilers
* Conversion for other utilisation
  UCG to OIL
  UCG to Fertilizer,Ammonia& Petrochemicals etc

7. Environment Impact Assessment

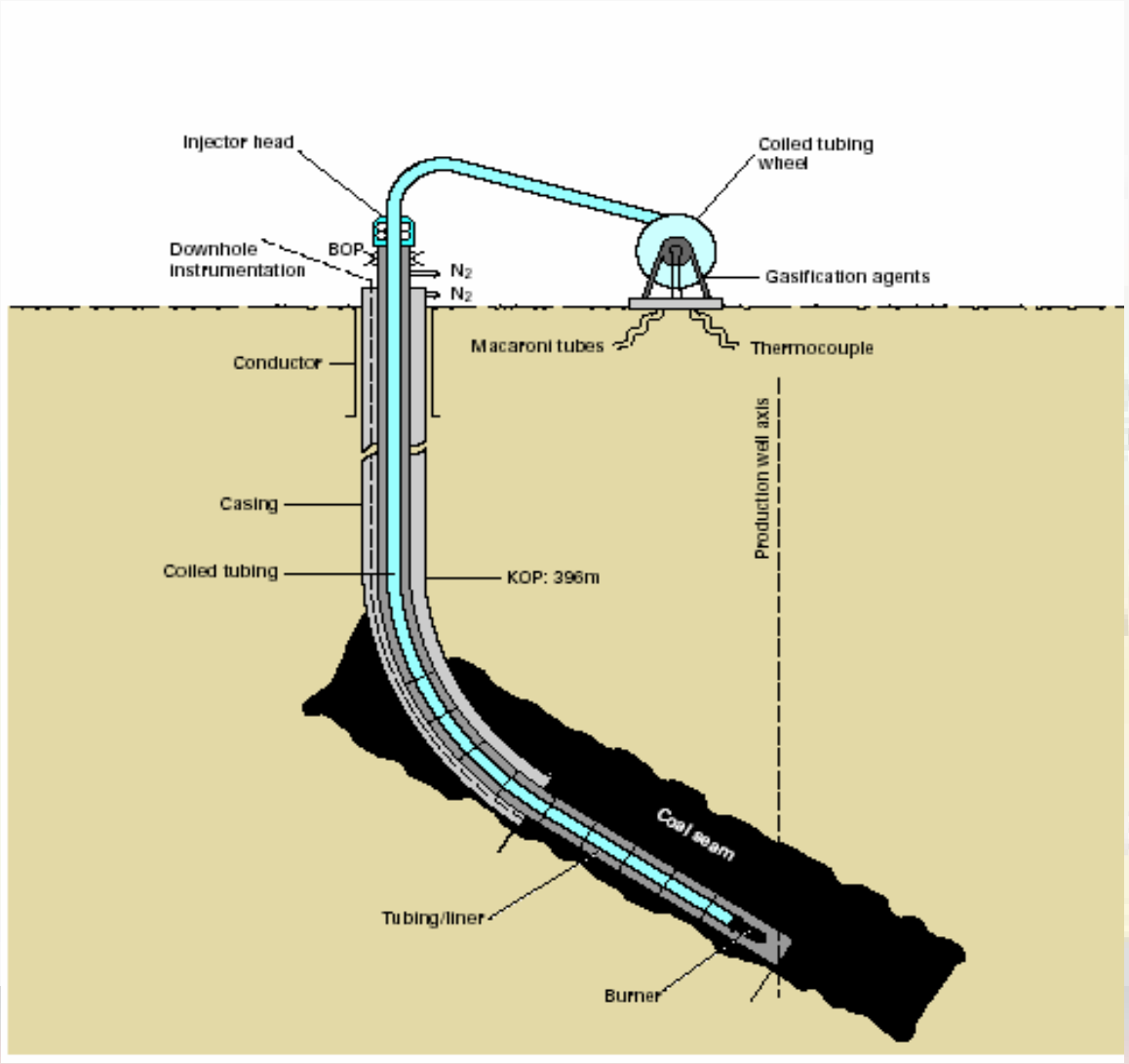
- Impact on Water

Monitoring Phenol,Tar, Trace Metals, BOD.etc in Ground & Surface Water

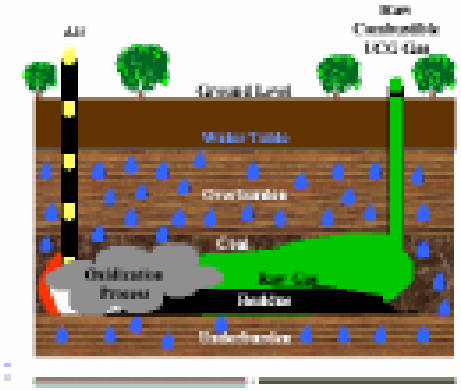
* Impact on Ambient Air

Particulates, Carbon Monoxide, Hydro Carbons (CnHm) etc

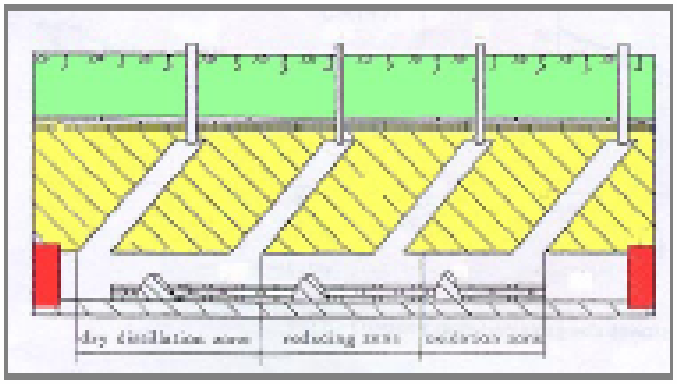
Controlled Retracatable Injection Procedure-CRIP in the inseam injection well of UCG



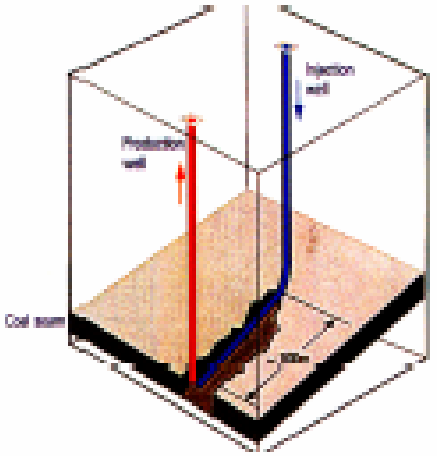
Three different Approaches to UCG



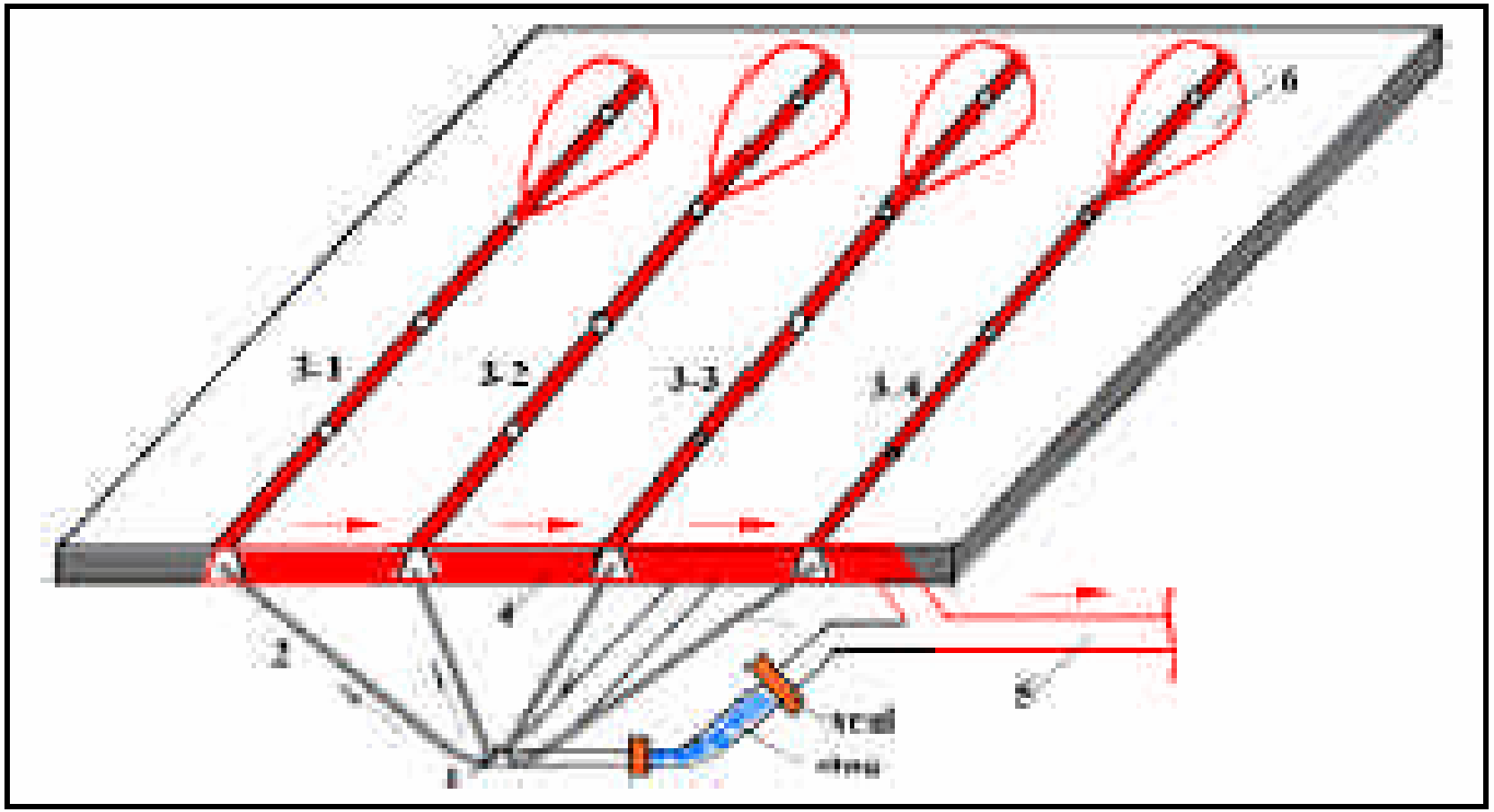
Chinchilla. Australia



Liuzhaung Mine, China



European UCG Trial, Spain



1——Injection Roadway　　2——Injection Holes
3——Gasification Drift　　4——Gas way
5——Main Gas Roadway　　6——Gasifier

Figure 1. The room-and-pillar UG concept

Overseas inseam drilling equipment

Drilling Rig S Africa

Schlumberger assembly

Australian directional drilling