UNDERGROUND COAL GASIFICATION IN INDIA

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PURPOSE

1. Provide an introduction to Underground Coal Gasification and Efforts of CMRI.

1. CMRI vision for UCG in India.

What is Gasification?

- Gasification is a general term for various processes that converts fuels such as coal into synthesis gas (Syngas) by reacting them with air/oxygen and steam at elevated temperatures.
- Gasification is not combustion.
- Syngas is primarily made up of CO, H_2 and CH_4.

Gasification (Contd..)

Partial Combustion	$C + O_2 = 2CO$	exothermic
Combustion	$C + O_2 = CO_2$	exothermic
	$C + CO_2 = 2CO$	endothermic
Water-Gas	$C + H_2O = CO + H_2$	endothermic
Hydrogasification	$C + 2H_2 = CH_4$	exothermic
Shift	$CO + H_2O = CO_2 + H_2$	exothermic
Reformation	$CO + 3H_2 = CH_4 + H_2O$	exothermic

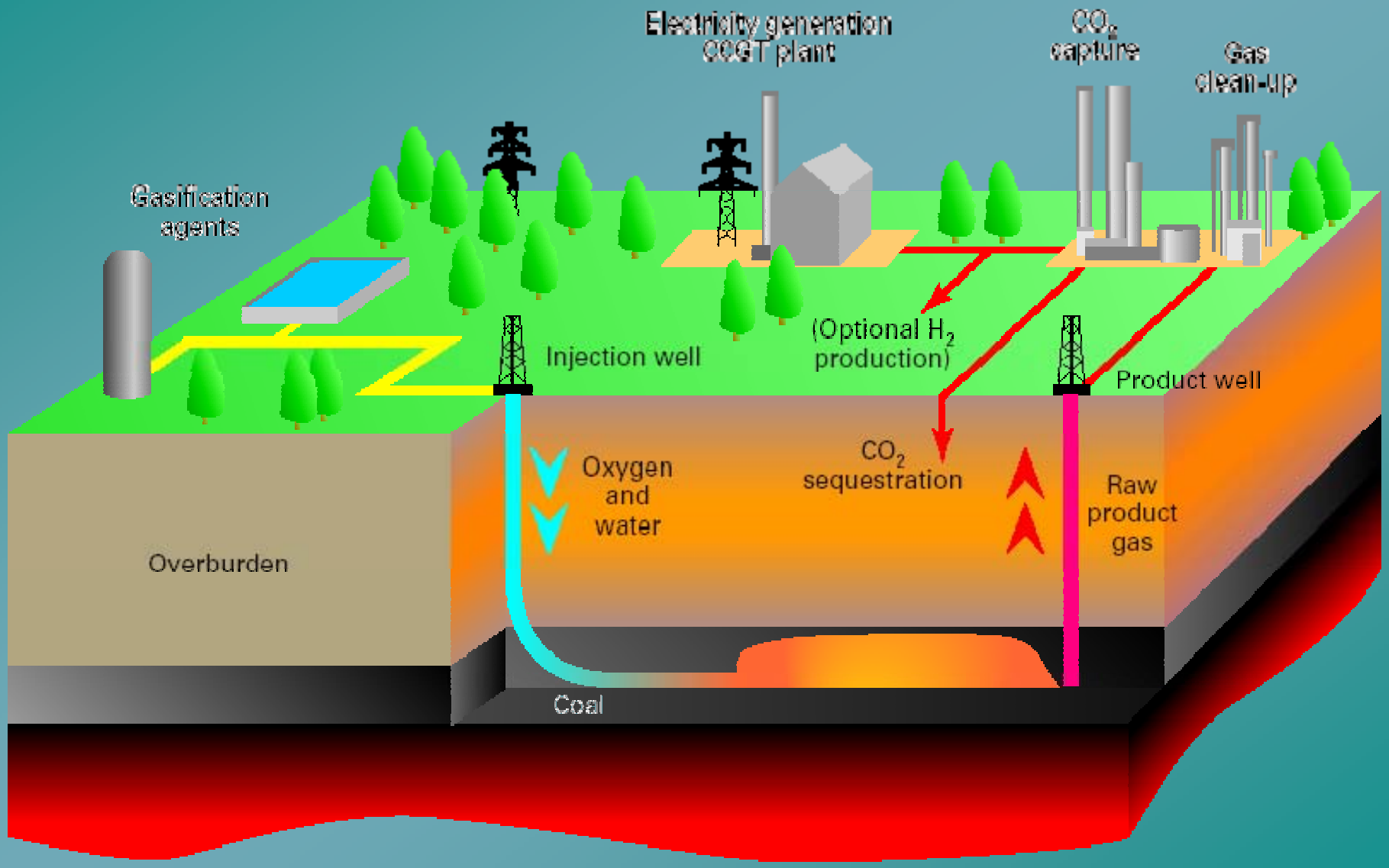
Gasification (Contd..)

- Gasification as a technology was developed in the early 1800's in Baltimore for town gas production.
- Today, gasification of coal is largely directed to the production for Syngas for conversion to ammonia, methanol etc.
- For power generation, it is expected to be the highest area of growth in gasification over the next 20 years.

Gasification (Contd..)

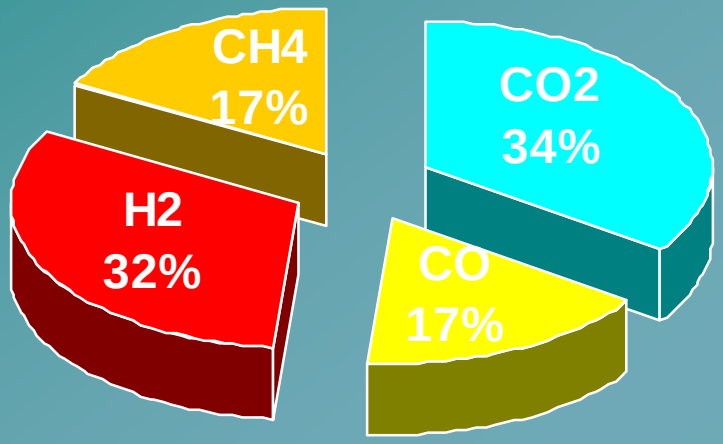
- **Surface Gasification**
  - **Moving bed or counter current flow reactors.**
  - **Fluidized bed or back mix reactors.**
  - **Entrained bed or plug flow reactors.**
- **Underground Coal Gasification (UCG)**

UCG


Electricity generation
CCGT plant
CO_2
capture
Gas
clean-up
Gasification
agents
Injection well
(Optional H_2
production)
Product well
Oxygen
and
water
CO_2
sequestration
Raw
product
gas
Overburden
Coal

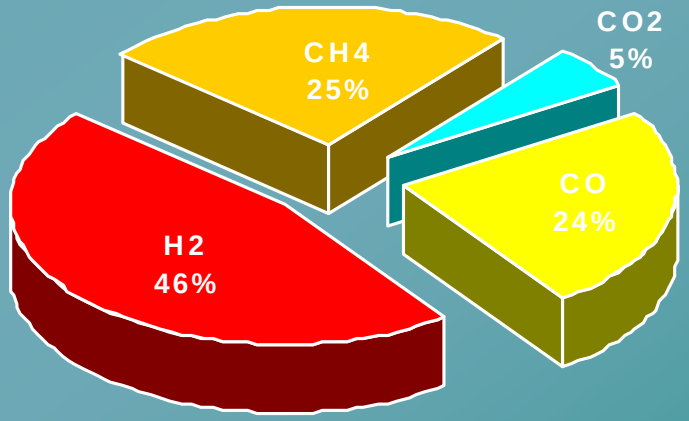
Gas Composition

Typical composition of UCG Dry Syn Gas



Calorific Value 2600 Kcal / sm^3

With no CO_2 capture



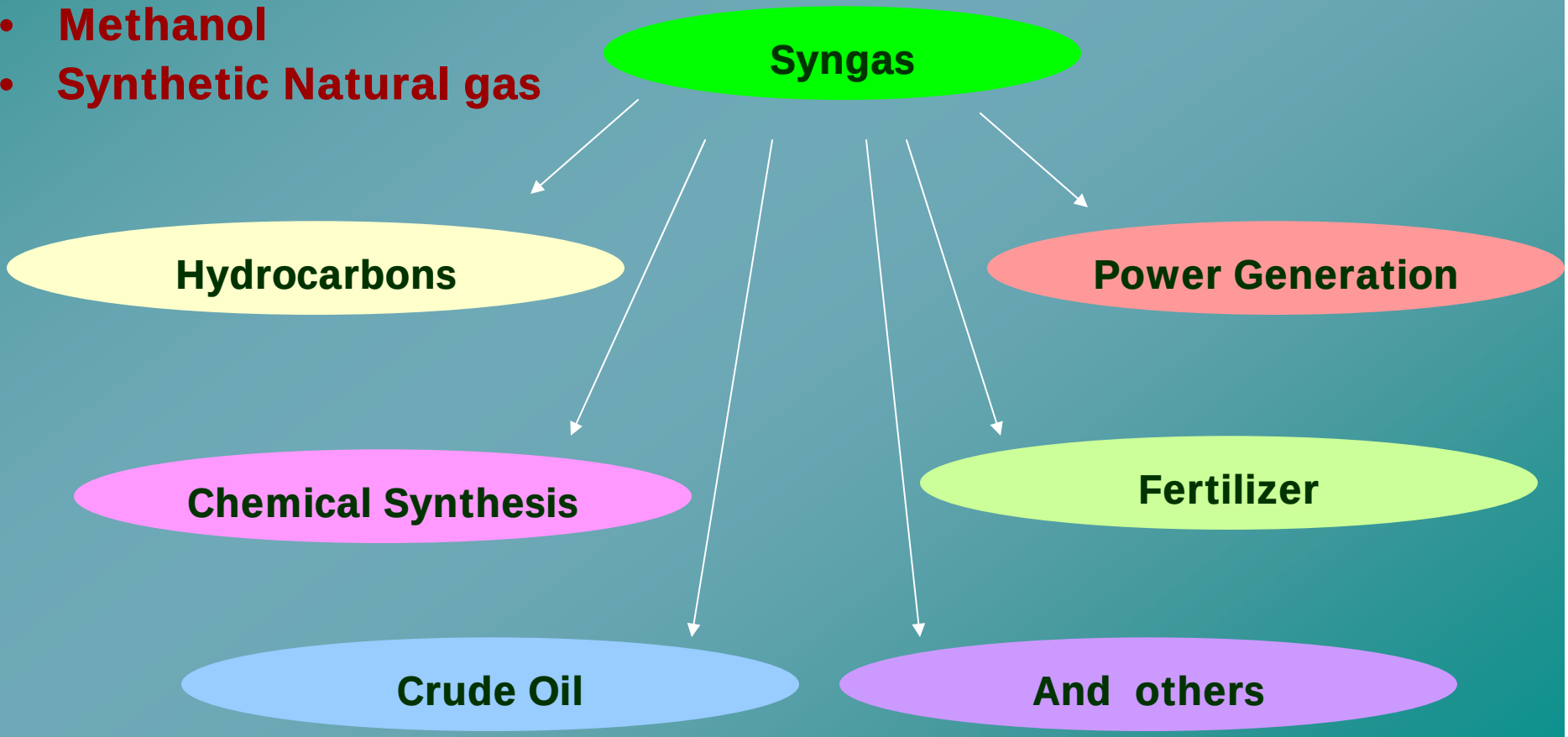
Calorific Value 4000 Kcal / sm^3

With CO_2 capture

After Blinderman et al. (2002)

Applications

- Produce Heat
- Generate Power
- Synthesis of Chemical products
- Hydrogen
- Methanol
- Synthetic Natural gas



Technology for Commercial Use

- Recent trials have established that viable solutions to the inseam connection problem can be achieved.
- Broadly, three methods of UCG have now evolved.
  - The first method, based on technology from the former Soviet Union, relies on vertical wells coupled generally with air pressurization to open up an internal pathway in the coal.

Technology for Commercial Use (Contd...)

- In the second Chinese method man-built galleries in the coal seam are used as the gasification channels, and boreholes are constructed to communicate with the surface.
- The third method, tested in European and American coal seams, is to create dedicated inseam boreholes, using drilling and completion technology adapted from oil and gas production, It has a moveable injection point known as CRIP.

The rate of production and composition of the product gas is a direct function of the following:

- **Pressure, flow rate and composition of the input gas, and catalyst.**
- **Characteristics of coal.**
- **Geologic conditions.**
- **Conditions created locally during linkage and gasification.**

Current Commercial Potential

- Chinchilla (Queensland, Australia) pilot plant has established:
  - Continuous gas production for 30 months.
  - Proven environmental acceptance.
  - Feasibility studies for power generation from 40 to 400MW, using proven plant.
  - Highly competitive economics (<US1.5c/kWh).

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%.

UCG in India

- In 1981 a protocol for UCG development was singed between the Government of India and the Government of erstwhile Soviet Union.
- In 1984 the Government of India constituted a National Committee on UCG.
- ONGC drilled two pilot wells near Mehsana city, in North Gujarat.

Results at Mehsana

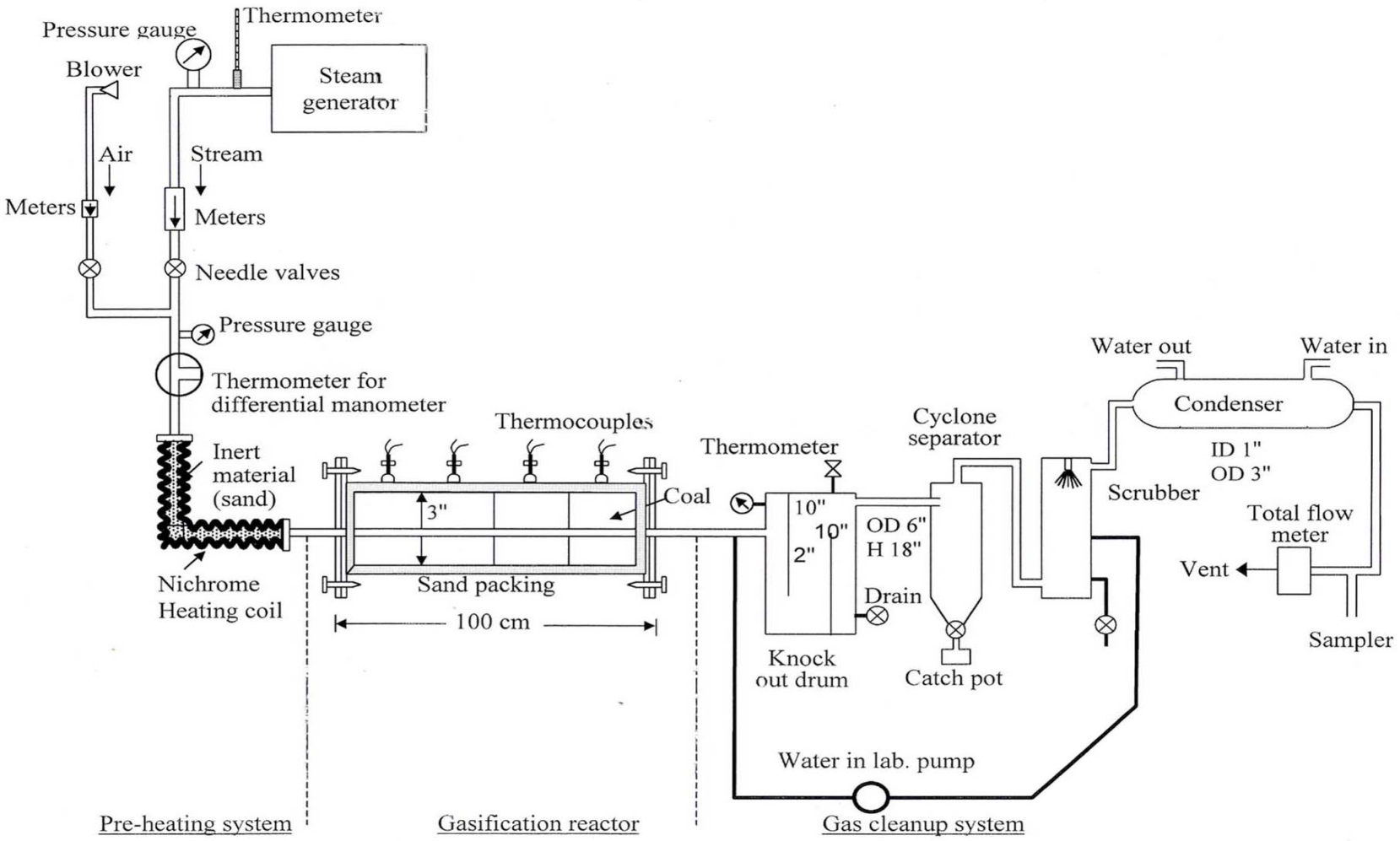
- Coal Reserves of about 63billion tones at a depths ranging from 700 - 1700m.
- Carbon content (dry ash free basis) between 72 – 76%
- Methane content varying from 1 – 6 m^3/t.
- Hydrogen content was high compared to other lignite deposits in India.

Recent Activities

- The Ministry of Coal, Government of India, has awarded an S&T study project to the Neyveli Lignite Corporation.
- ONGC has signed an Agreement for Collaboration with Skochinsky Institute of Mining, Russia in Nov. 2004.
- ONGC has also signed a MOUs with NLC, GMDC, GIPCL, CIL and SCCL.
- Vastan mine block of GIPCL has been identified suitable for UCG.
- Five additional blocks are also being studied.
- Five blocks were found NOT suitable.
- GAIL signed MoC with Ergo Exergy, Canada and MoU with Govt of Rajasthan. Land has been earmarked to GAIL.

Efforts of CMRI

- In 1984 the Government of India constituted a National Committee on UCG with Prof. M.M. Sharma as the Chairman.
- CMRI was one of the participating institutions.
- The coal samples of different coal seams were evaluated for their detailed In-situ gas content, petrology, reactivity and physico-mechanical properties etc. Water samples were examined.
- CMRI conducted laboratory studies with lab scale physical models.


Pressure gauge
Thermometer
Blower
Steam generator
Air
Stream
Meters
Meters
Needle valves
Pressure gauge
Thermometer for differential manometer
Inert material (sand)
Thermocouples
Thermometer
Cyclone separator
Water out
Water in
Condenser
ID 1"
OD 3"
Scrubber
Total flow meter
Vent
Sampler
Coal
3"
10"
10"
2"
OD 6"
H 18"
Drain
Nichrome Heating coil
Sand packing
100 cm
Knock out drum
Catch pot
Water in lab. pump
Pre-heating system
Gasification reactor
Gas cleanup system

Components of Lab scale model

- Feed gas preheating system.
- Gasification reactor.
- Gas clean-up and sampling system.

Coal Used

Percentage of ash	- 19.00
Percentage of moisture	- 04.02
Percentage of volatile matter	- 27.06
Percentage of fixed carbon	- 49.92

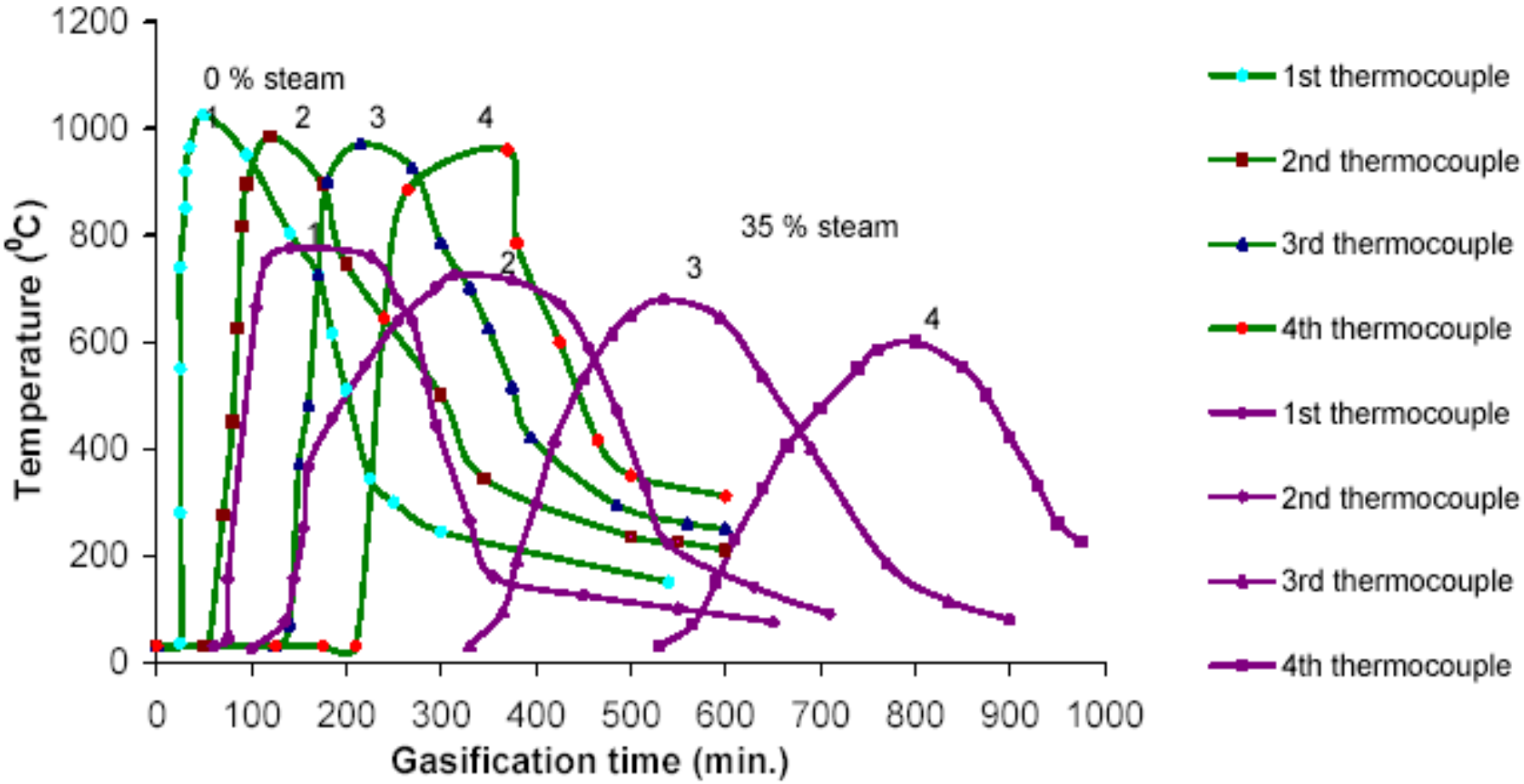
Findings of Lab scale model

- With the oxidation zone at the thermocouple point I, indicated by maximum rise in temperature, the highest content of CO_2 in product gas was indicated. A significant decrease in the residual content of oxygen was shown at the same time.
- As the oxidation zone reached second thermocouple point lowest residual content of oxygen was obtained with the least amount of CO_2 content for a run.
- Also, steep increase in CO_2 and H_2 content in the product gas was obtained. Thereafter, CO_2 content in the product increased, rather moderately.

Findings of Lab scale model

- It was found that addition of steam to the injection blast, generally, lowers the temperature of the reaction zones and thus improves the gasification efficiency.
- Large proportion of steam, however, slows the gasification due to further lowering of temperature in reaction zones.

Findings of Lab scale model



Background paper on UCG

- Prepared a background paper on UCG for TIFAC.

- Global technological status, Barriers, Technological and policy interventions required and prospects of UCG in India have been highlighted in this work.

CMRI Facilities for UCG

- **Development of lab scale reactors to study the characteristics of coal for the purpose of gasification.**
  - Impact of temperature variation.
  - Variation of feed rate and composition.
  - Molecular composition of gases evolved with different ramp rate and temperature range.

CMRI Facilities for UCG

- Numerical modelling of coal and char reactions, fluid flow and heat transfer, breakage and collapse of rock and coal to predict:

  - Cavity volume changes.
  - Product gas flow rate and composition.
  - Modelling strata mechanics and subsidence.
  - Opportunities for filling voids, if required.
  - Ground water depletion and contamination.
  - Preparation of EIA and EMP for UCG projects.

Future programme

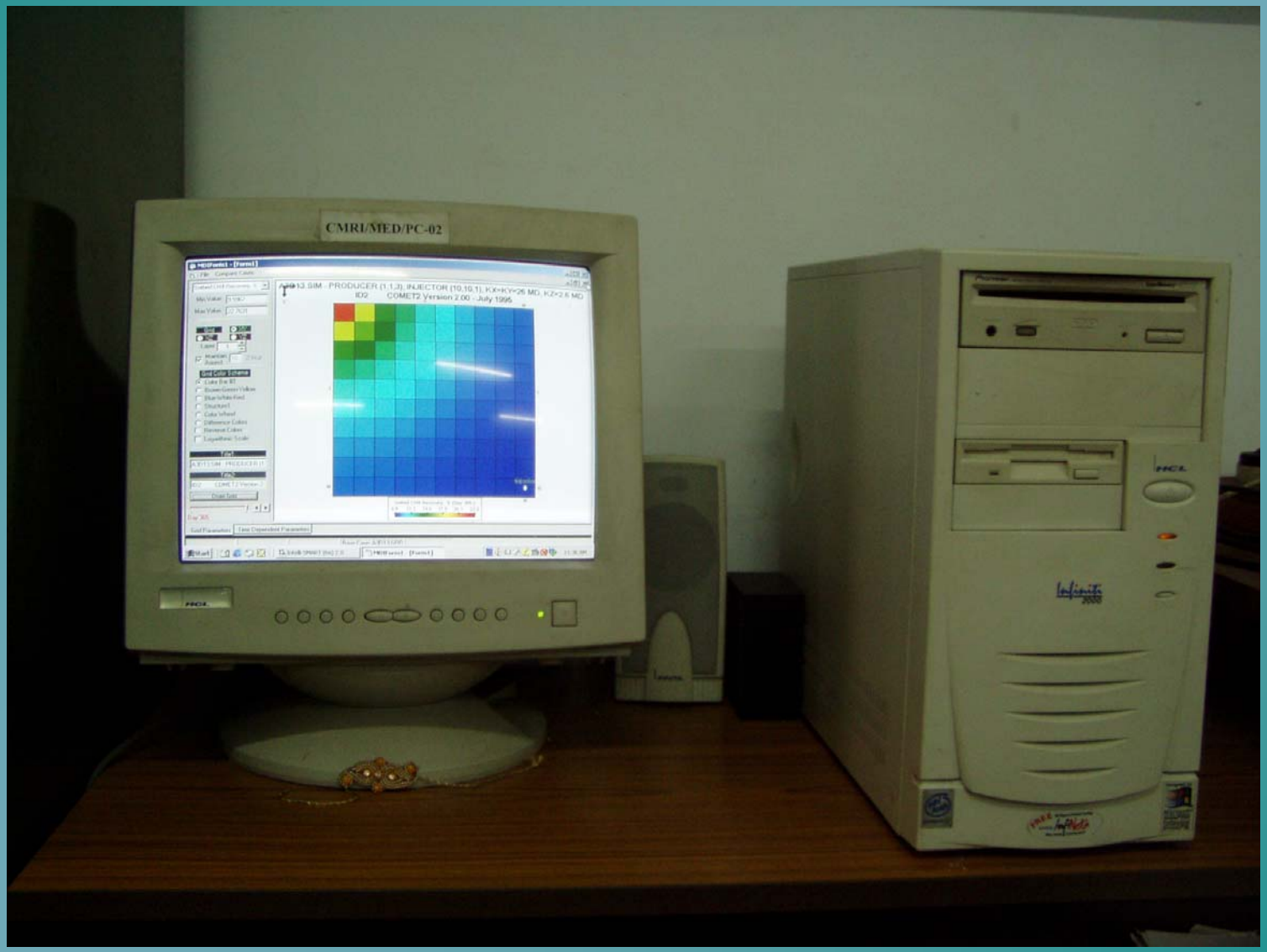
- Compilation of general characteristics of coal seams and identification of suitable sites for UCG.
- Evaluation of Technical and Economic Indices.
- Studies on geology of UCG blocks,coal quality, roof and floor rock lithology, geohydrology, geological models and numerical modelling to assist a UCG - Pilot programme.
- Assessment of CO_2 capture and storage potential in cooled cavities.

Adsorption Isotherm

Equilibrium Moisture

Gas Chromatograph

Reservoir Modelling



Core Permeability / porosity

Rock mechanics lab

- Consortium of Public Sector Companies, National laboratories like CMRI and Academic Institutes.
- A national mission project may be undertaken.
- Guidance of expert consultants.
- Lab scale studies may be initiated immediately.
- Pilot scale demonstration project.

THANKS