Polish Activities in Underground Coal Gasification

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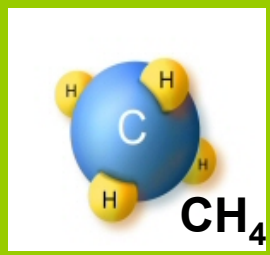

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- *General Principles - Definitions*
- *Coal Gasification Process*
- *Underground Coal Gasification (UCG)*
- *Polish Activities in Underground Coal Gasification*
- *Conclusions*

General Principles - Definitions

Coal Gasification
Conversion of coal into gaseous products in a gasification reactor using air, oxygen, steam…

Underground Coal Gasification
Conversion of coal into gaseous products directly in the coal seam using air, oxygen, steam…

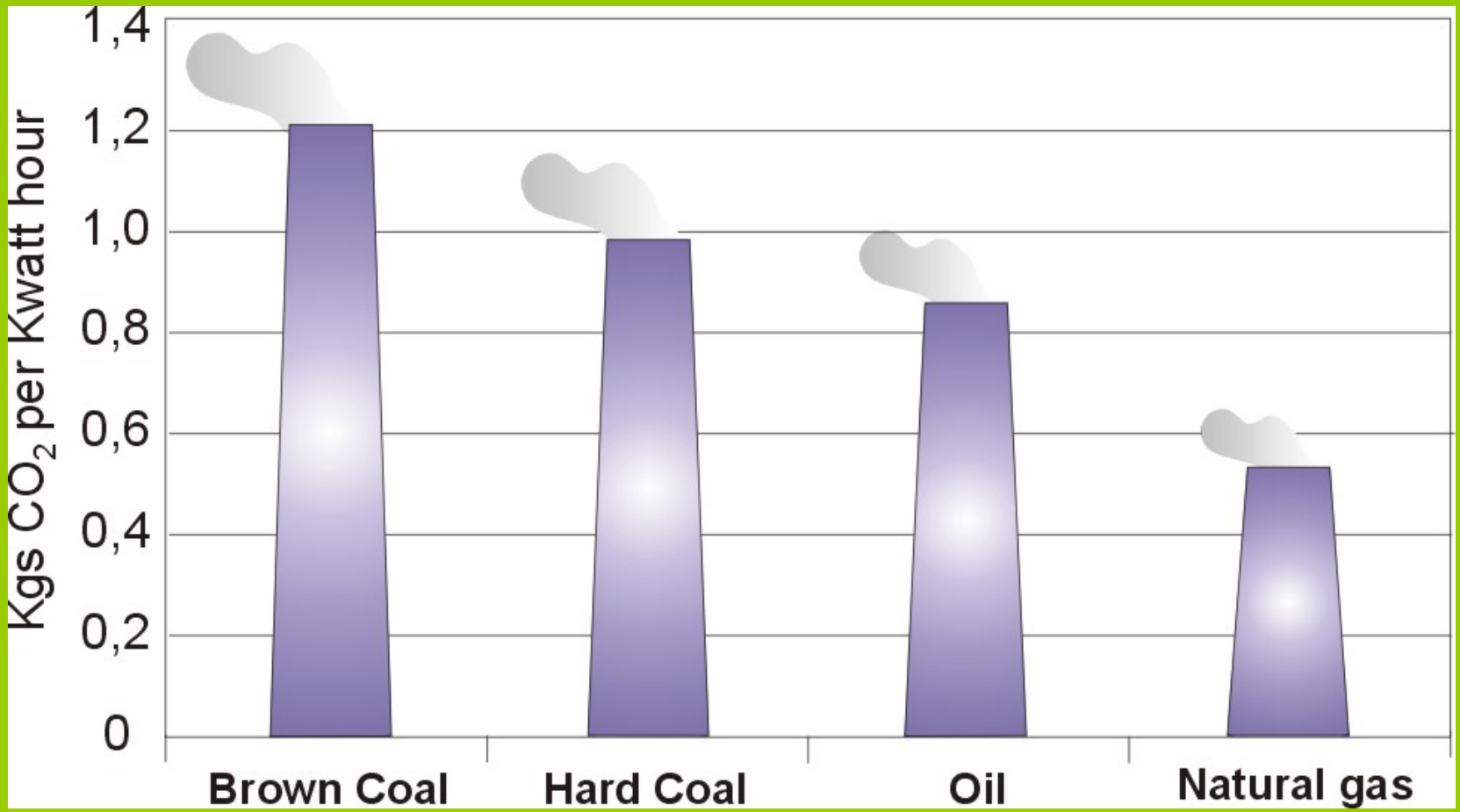
CO_2 underground sequestration
Storing carbon dioxide inside coal seams or reservoirs far below the Earth's surface

General Principles - cont.

COAL
CHALLANGES, TECHNOLOGIES

- **Increased efficiency of electricity generation**
  - ***Oxy –combustion:***
    (Advanced Supercritical Bituminous Pulverised Fuel -Fired Power Plant, Natural Gas Combined Cycle Power Plant)
  - ***High temperature fuel cell***
  - …..
- **Conversion to gas or liquid fuels**
- **Underground coal gasification**
- **Carbon dioxide sequestration**

CO_2 Emission



http://www.greenhous.gov.au

What is gasification?

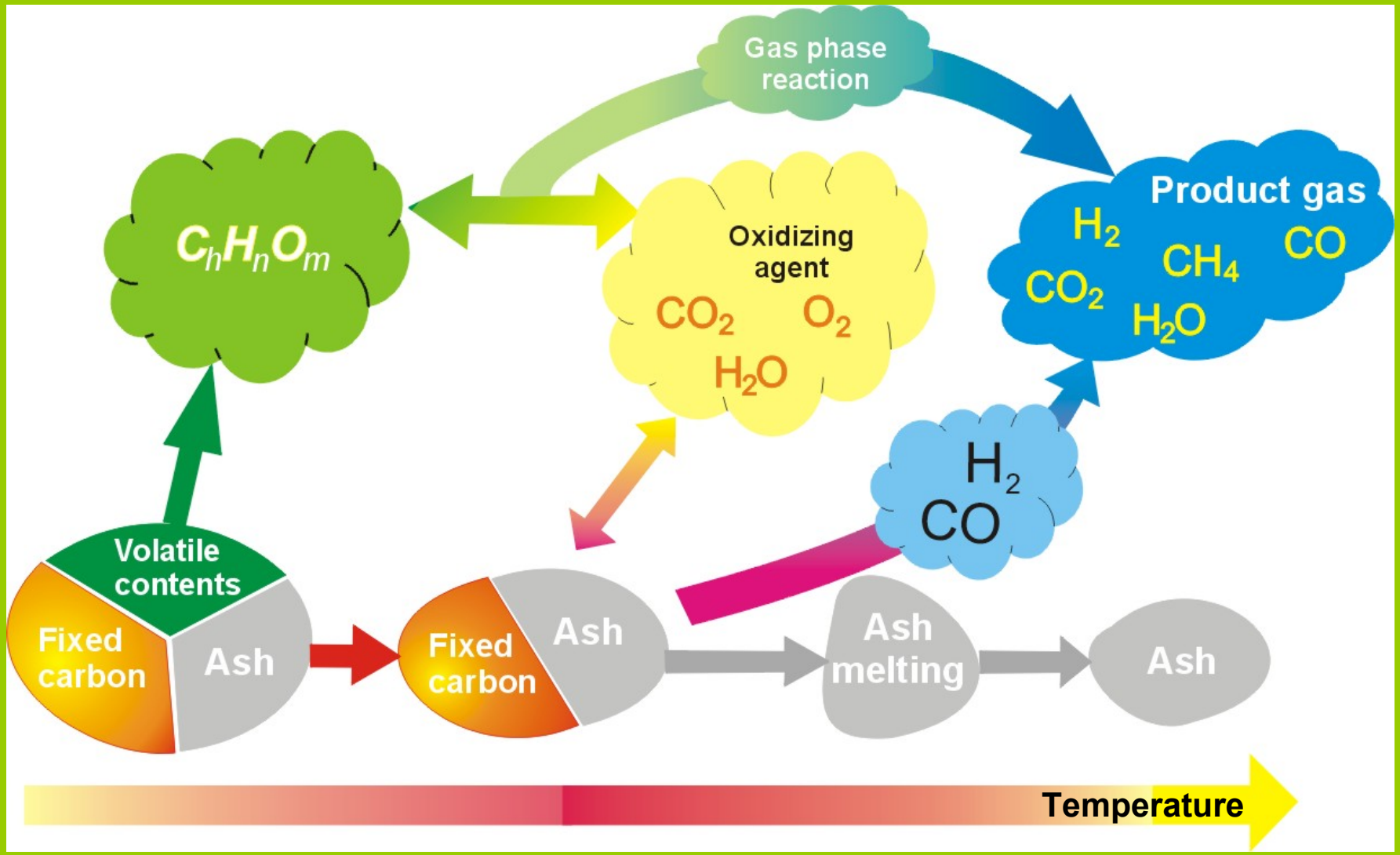
Gasification **is a controlled partial oxidation of coal to produce primarily carbon monoxide (CO) and hydrogen (H_2)**

Combustion **is a conversion of coal into carbon dioxide (CO_2) and water (H_2O) and …**

- Gasification: $(C_m H_n) + ½ O_2 \rightarrow CO + H_2$

- Combustion: $(C_m H_n) + O_2 \rightarrow CO_2 + H_2O$

Coal Gasification Process



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Gases from Coal Gasification

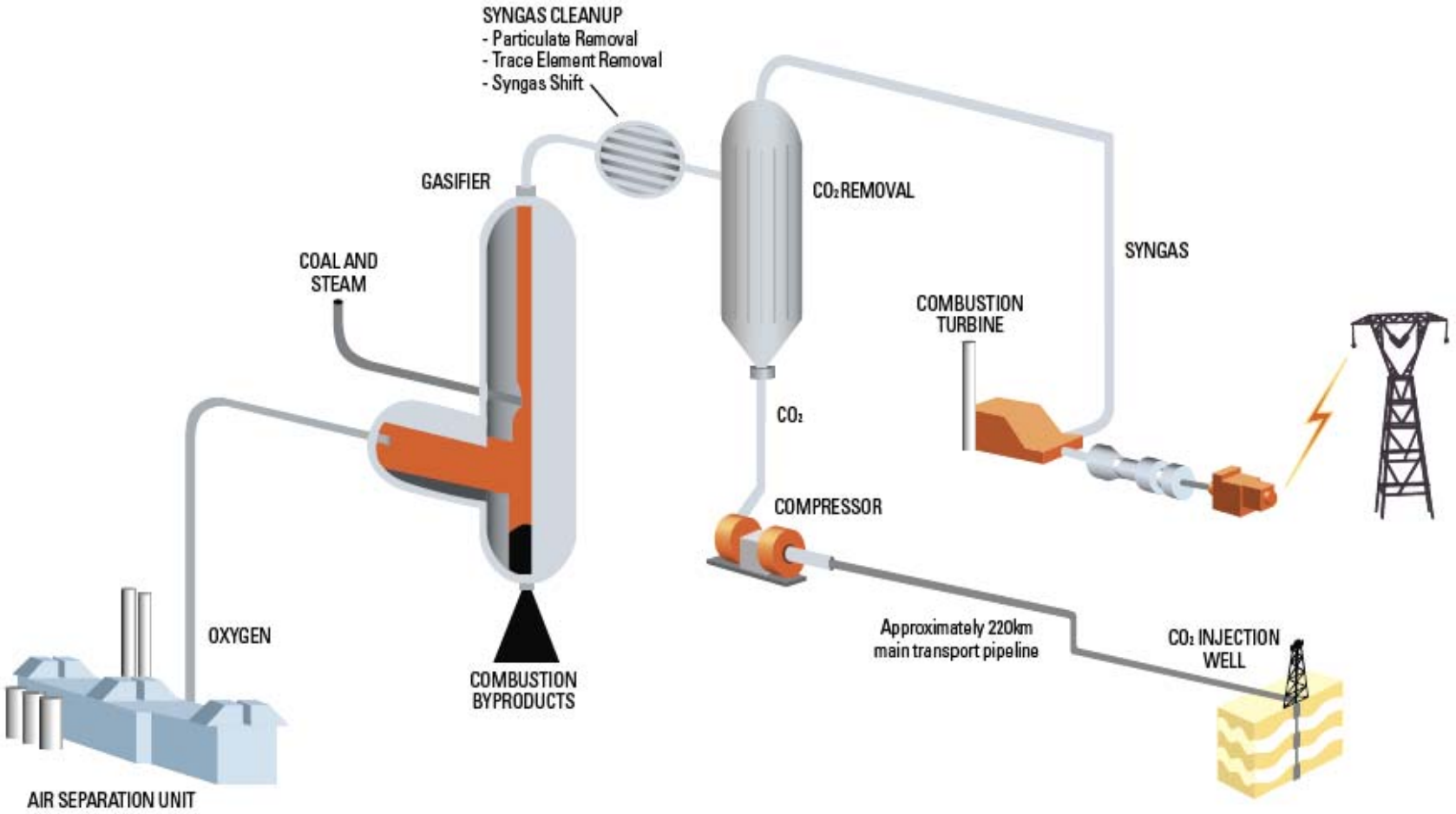
1. Coal + air $\rightarrow$ CO + H_2 + N_2 producer gas
   (C) (O_2+N_2)

2. Coal + air + steam $\rightarrow$ CO + H_2 + N_2 water gas
   (C) (O_2 + N_2) (H_2O)

3. Coal + oxygen + steam $\rightarrow$ CO + H_2 synthesis gas syngas
   (C) (O_2) (H_2O) (SNG)
   $\searrow$
   CH_4

Synthesis gas can be used to produce hydrogen (H_2)

ZeroGen Demonstration Project Schematic

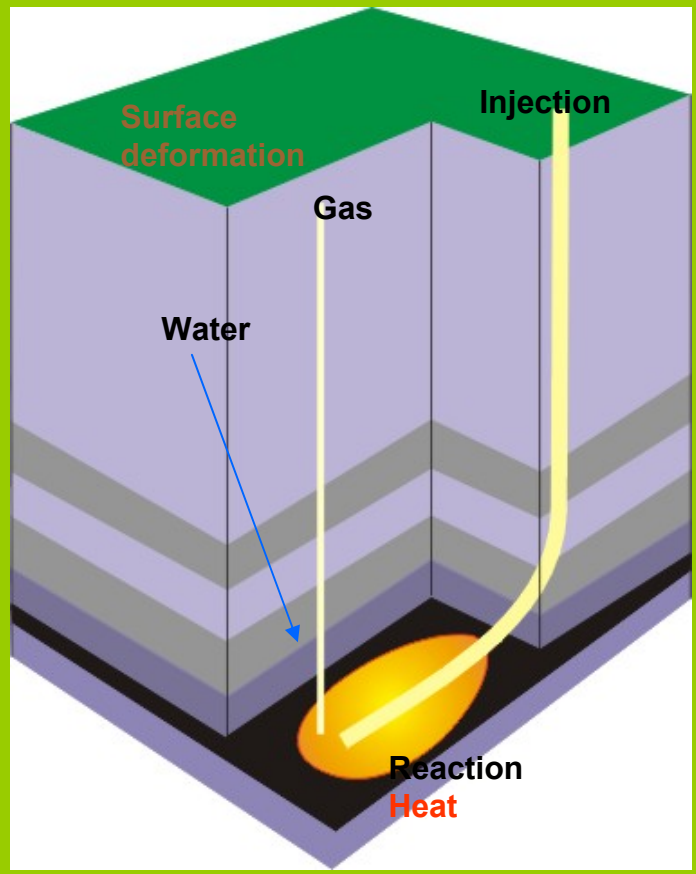


STANWELL CORPORATION LIMITED

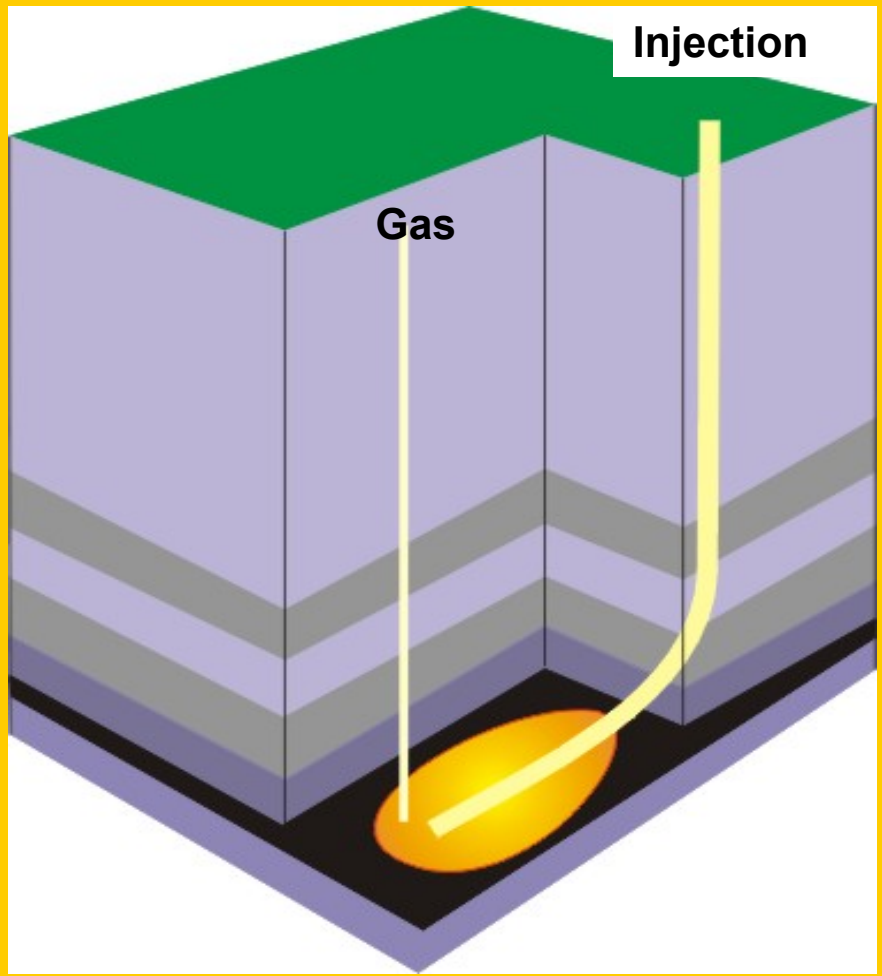
What is UCG?

UCG processes are complex involving:

- Injection processes and gas flow
- Chemical reactions
- Heat and mass transfer
- Water flow
- Thermo- mechanics of coal and rock mass
- Physical site changes



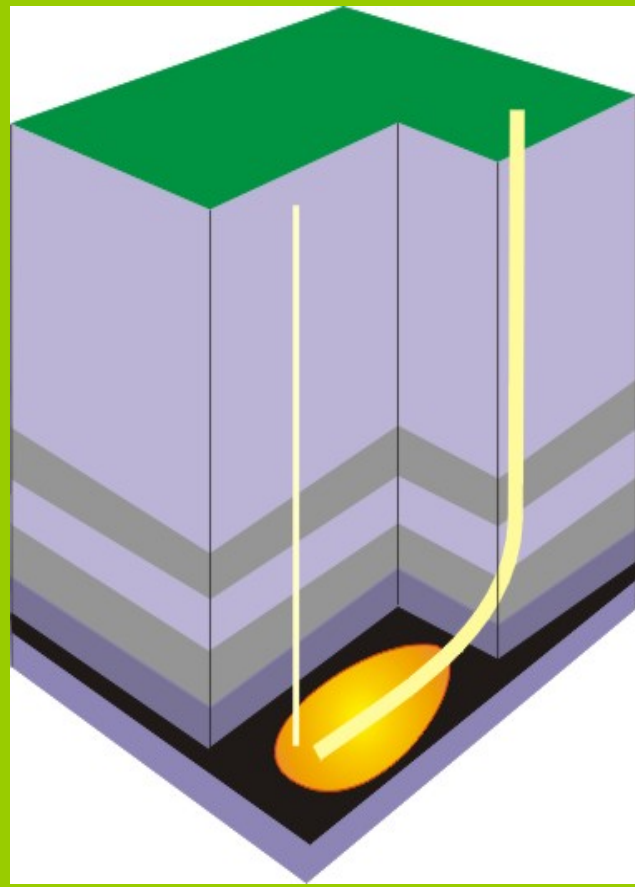
Underground Coal Gasification (UCG)



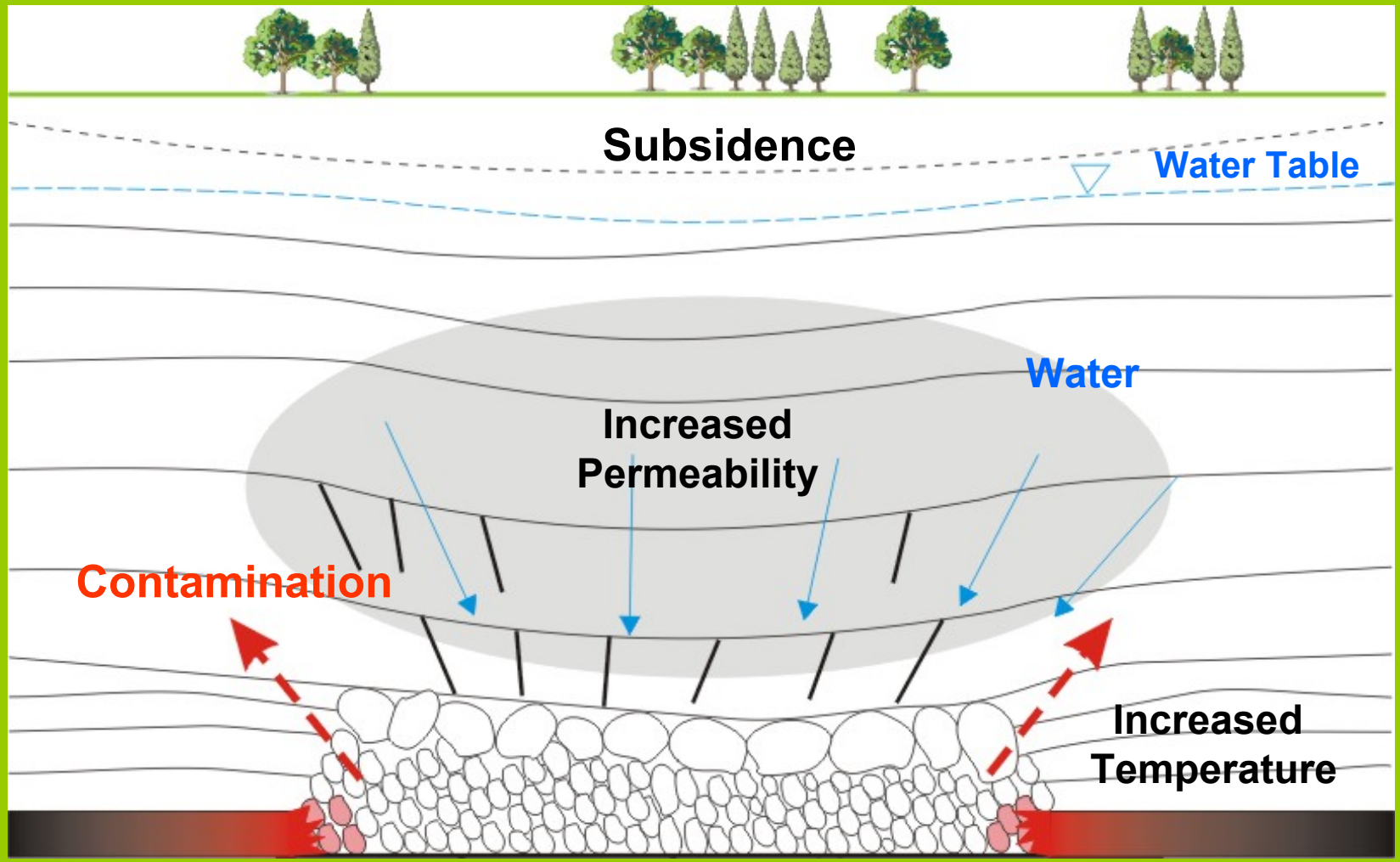
1. UCG is a clean method - only gas is removed from the coal seam, leaving all the ash and slag underground
2. UCG reduces greenhouse gas emissions (significant low sulfur oxide and nitrogen oxide emission)
3. High CO_2 partial pressure – smaller capture plant
4. Self-sustaining for water injection

What affects UCG?

- Coal seam depth, thickness and dip
- Coal permeability
- Overburden properties
- Hydrogeology
- Drilling capabilities
- Required production volume
- Restrictions on subsidence and groundwater consumption



Rockmass Deformation



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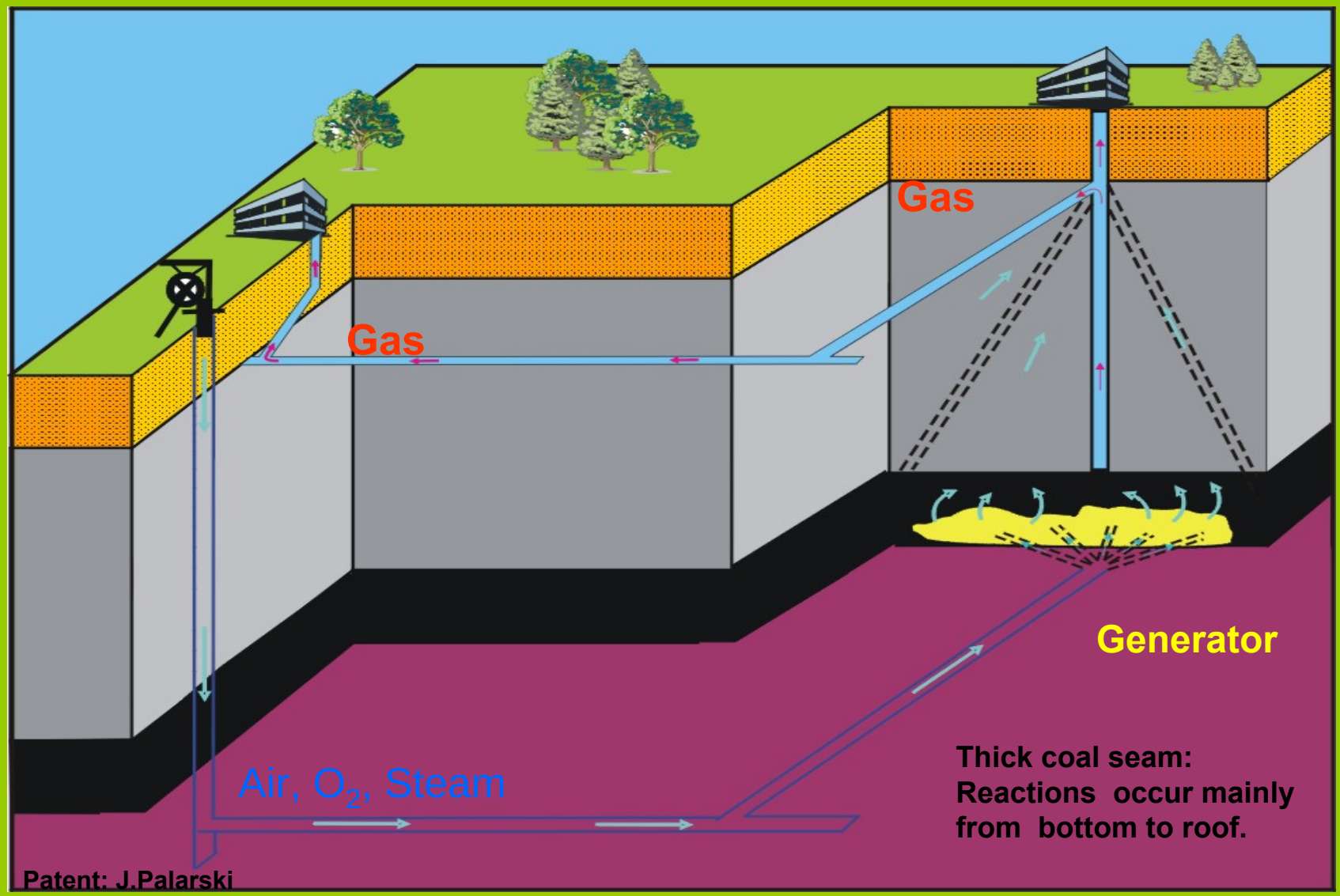
UCG Efficiency

	Efficiencies
Current traditional coal burning	*30% - 38%*
Current gasification	*50%*
Future gasification	*70-80%*

Coal gasification **is much more efficient than coal burning in power plants**

UCG – Pilot Technology

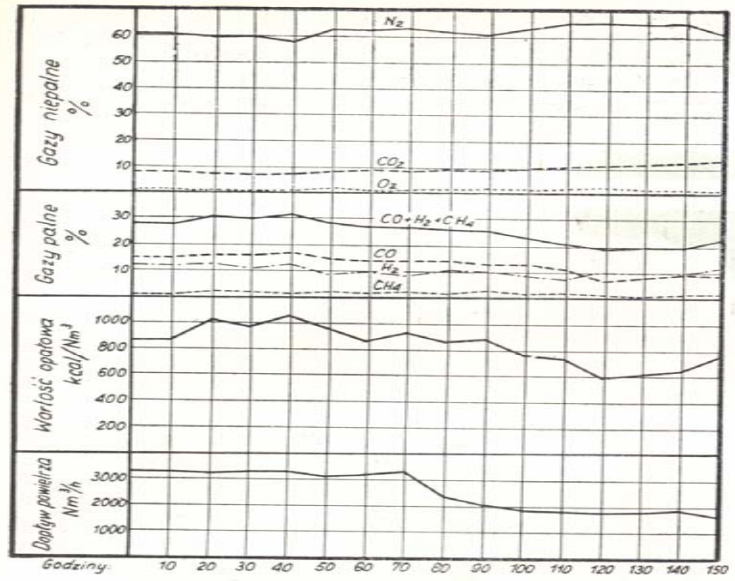


Future generators will be prepared from directionally drilled borehols.

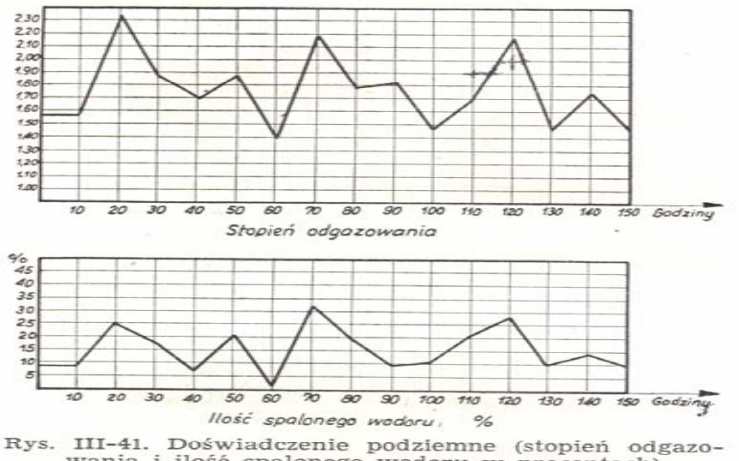
UCG in Poland

Some important dates in connection with UCG in Poland

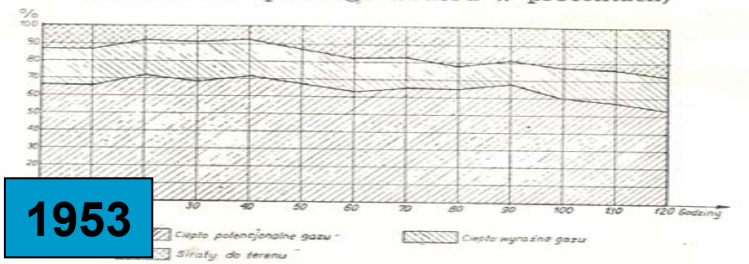
1950 –	**first UCG tests in laboratory**
1953 –	**underground experiments with coal gasification at mine Mars**
Early 1980-s	**some UCG modelling was conducted**
2007	**new experiments with UCG**



Rys. III-40. Doświadczenie podziemne (wyniki zgazowania powietrzem)



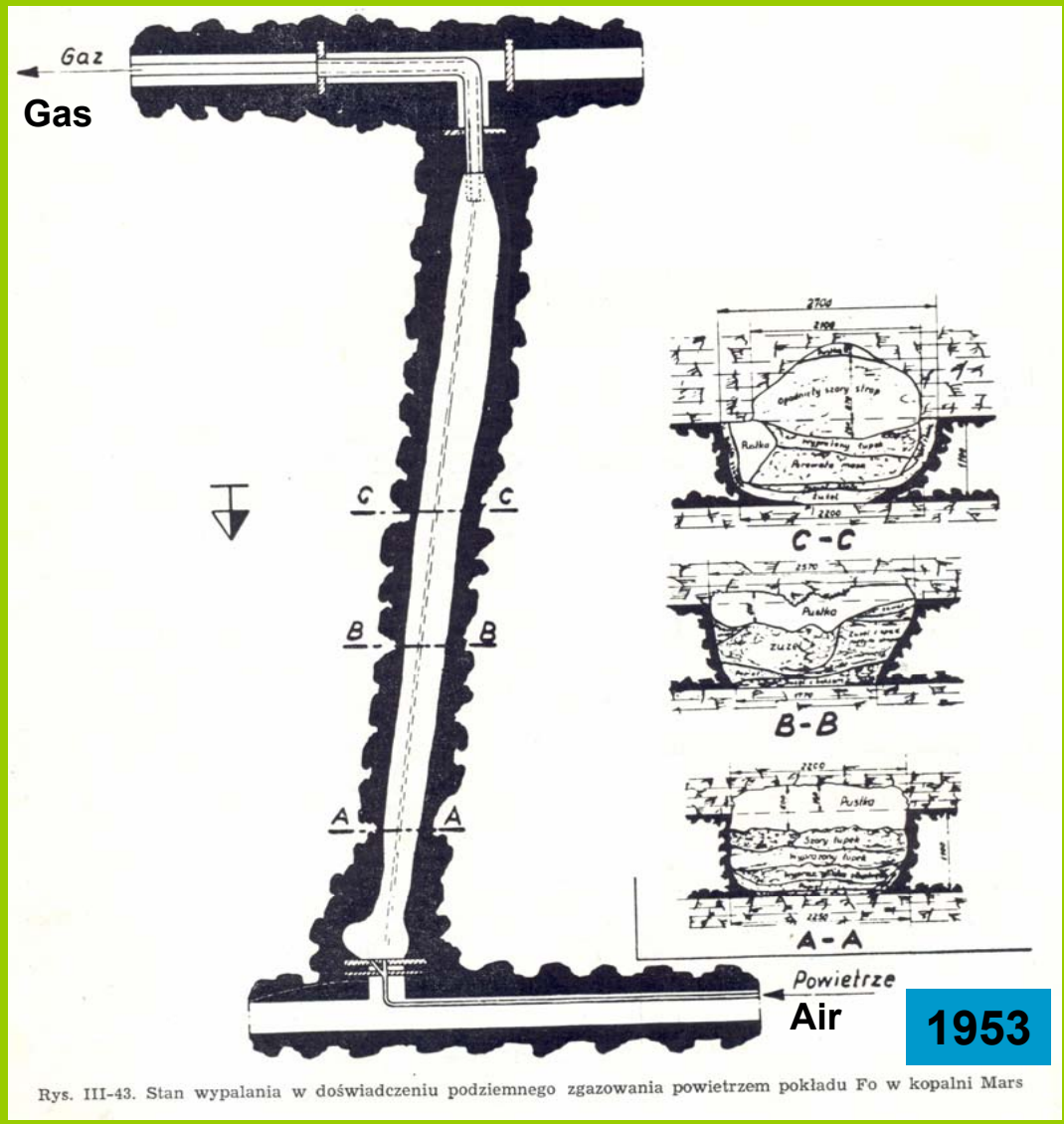
Rys. III-41. Doświadczenie podziemne (stopień odgazowania i ilość spalonego wodoru w procentach)



1953

Rys. III-42. Obraz bilansu energetycznego z doświadczenia zgazowania węgla kamiennego powietrzem zimnym w generatorze podziemnym

UCG in mine Mars/Poland (1953)



Rys. III-43. Stan wypalania w doświadczeniu podziemnego zgazowania powietrzem pokładu Fo w kopalni Mars

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SPONTANEUS COMBUSTION OF COAL

Polish Activities in Underground Coal Gasification

1. **Hydrogen Oriented Underground Coal Gasification for Europe – Project HUGE (RFCS –EU)**

2. **Pilot Project of Massive Production of Hydrogen from Coal Seams - The Private Investors**

UCG Project „HUGE”

Hydrogen Oriented Underground Coal Gasification for Europe

- Starting date: 01. July 2007
- Project duration: 36 months
- Total costs: ca. 3.2 Mil. EURO

Project summery

- The project explores the technology for ***hydrogen*** production through ***underground*** gasification of coal in a ***dynamic geo-reactor***

- The process will be controlled through purposed dynamic changes in temperature and pressure of the reactants and products

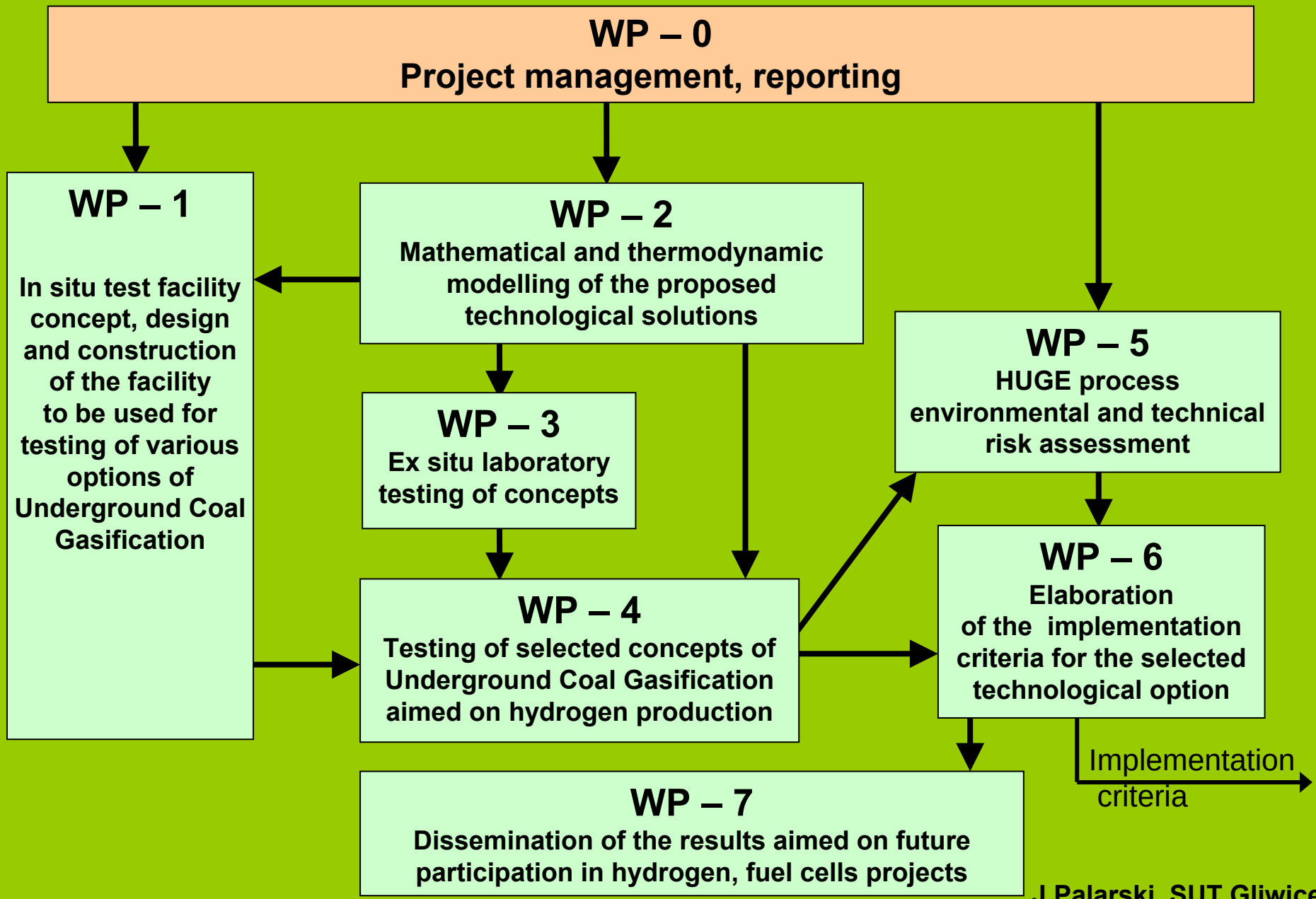
- The project addresses CBM usage and CO_2 sequestration in coal deposits

- The locations of demonstration plants will be chosen through computer modelling and simulation – Silesia Region Poland

Consortium Partners

Glowny Instytut Gornictwa (GIG)	Poland
Politechnika Slaska (SUT)	Poland
Kompania Weglowa SA (KW SA)	Poland
BOT Górnictwo i Energetyka S.A. (BOT GiE SA)	Poland
Poltegor Institute (IGO)	Poland
Delft University of Technology (TUD)	The Netherlands
Universität Stuttgart (USTUTT)	Germany
Institute of Chemical Process Fundamentals AS CR (ICPF)	Czech Republic
Institut Scientifique de Service Public (ISSeP)	Belgium
The UCG Patnership LTD (UCGP)	Great Britain
National Mining Academy (NMA)	Ukraine

Project Activities



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Based on the mining concession which covers the area of 627 km²
in Upper Silesia and the private investors

the **PILOT PROJECT**
of **Massive Production of Hydrogen from Coal Seams** is started.

The Super Daisy Shaft system and underground pyrolytic conversion of coal with steam and oxygen (without NOx) into synthesis gas, hydrogen & electric energy will be established.

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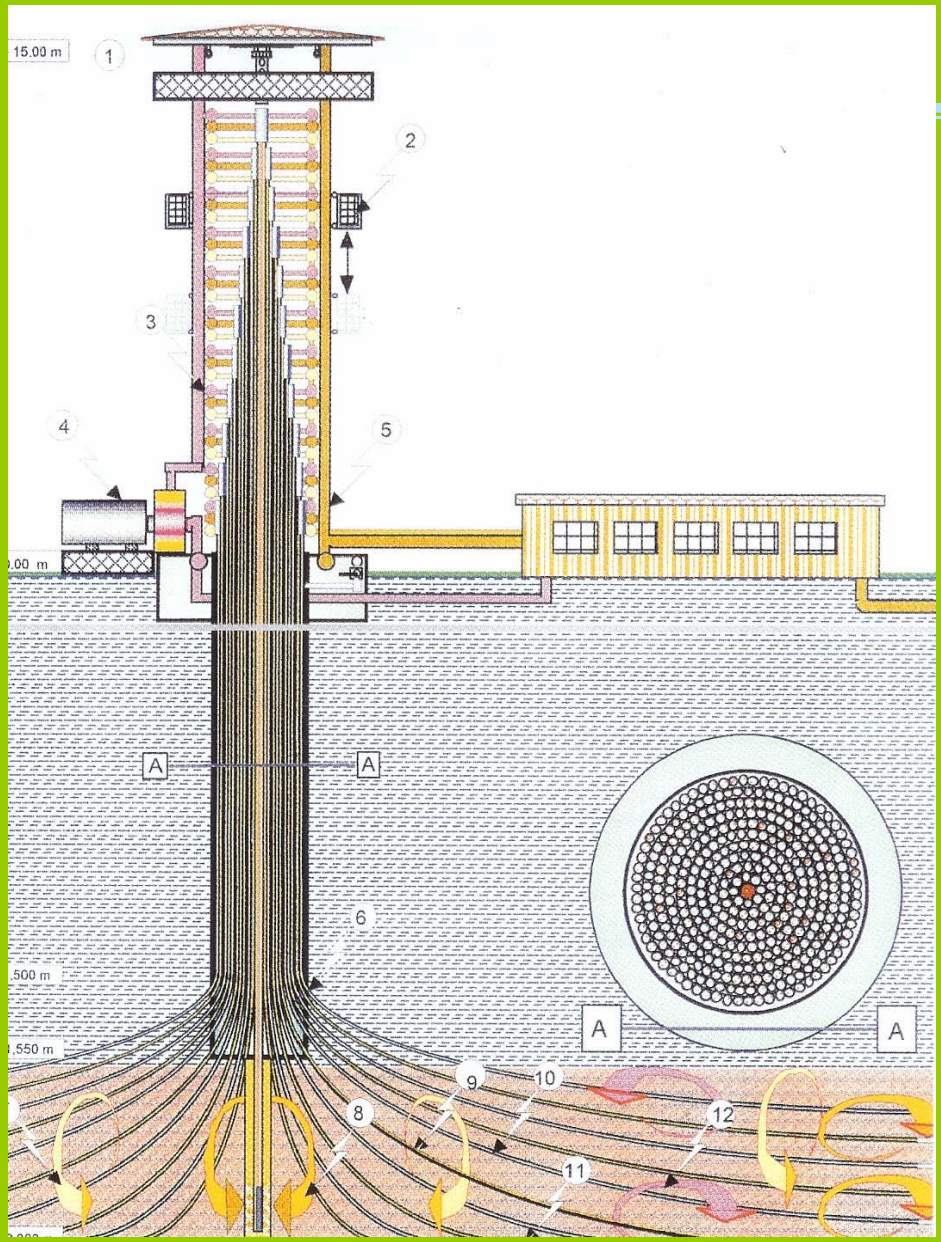
Crossection of Super Daisy Shaft



equipped with Multitude of production Multifunction, small diameter Jet Stngers, which can recover from area space of 15 sq. km:

1. **Combustion gasses: CO or CO_2**
2. **Energy steam from combustion**
3. **Geothermal Energy**
4. **Liquefied Sulphur**
5. **Oil Crudes**
6. **Ultra-Heavy hydrocarbons**
7. **Dissolved Salts**
8. **Leached Metals & Uranium**
9. **Processed Bio-products from Lignites**
10. **Water Intakes & Mines dewatering**

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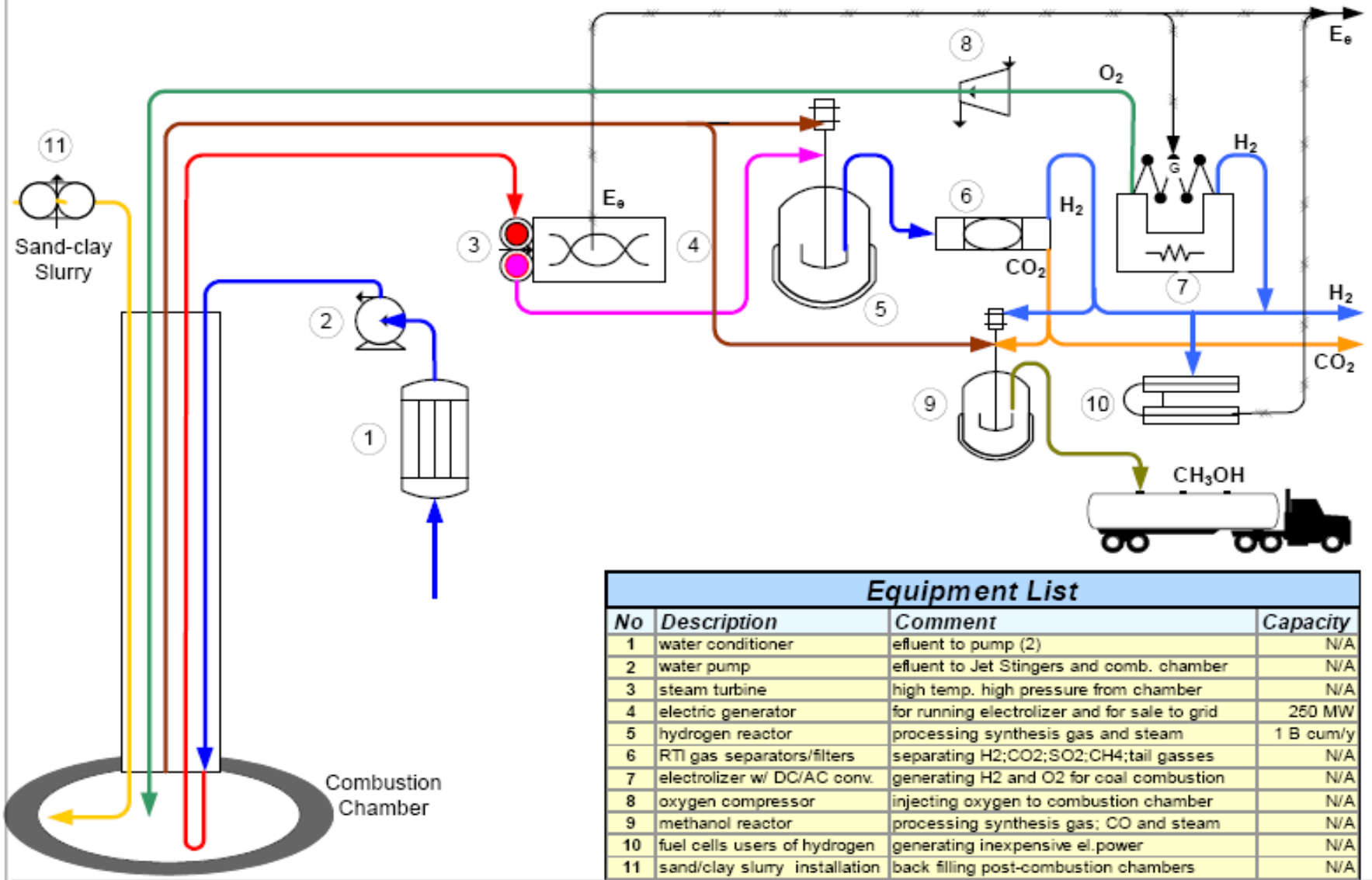
SUPER DAISY SHAFT SYSTEM

Consolidated Seven Rocks Mining, Ltd.

Hydrogenium Suprematio Project



Equipment List

No	Description	Comment	Capacity
1	water conditioner	effluent to pump (2)	N/A
2	water pump	effluent to Jet Stingers and comb. chamber	N/A
3	steam turbine	high temp. high pressure from chamber	N/A
4	electric generator	for running electrolizer and for sale to grid	250 MW
5	hydrogen reactor	processing synthesis gas and steam	1 B cum/y
6	RTI gas separators/filters	separating H2;CO2;SO2;CH4;tail gasses	N/A
7	electrolizer w/ DC/AC conv.	generating H2 and O2 for coal combustion	N/A
8	oxygen compressor	injecting oxygen to combustion chamber	N/A
9	methanol reactor	processing synthesis gas; CO and steam	N/A
10	fuel cells users of hydrogen	generating inexpensive el.power	N/A
11	sand/clay slurry installation	back filling post-combustion chambers	N/A

Author: Dipl.Eng. Bohdan M. ZAKIEWICZ, PhD

MASSIVE PRODUCTION OF HYDROGEN FROM COAL SEAMS

Production Capacity

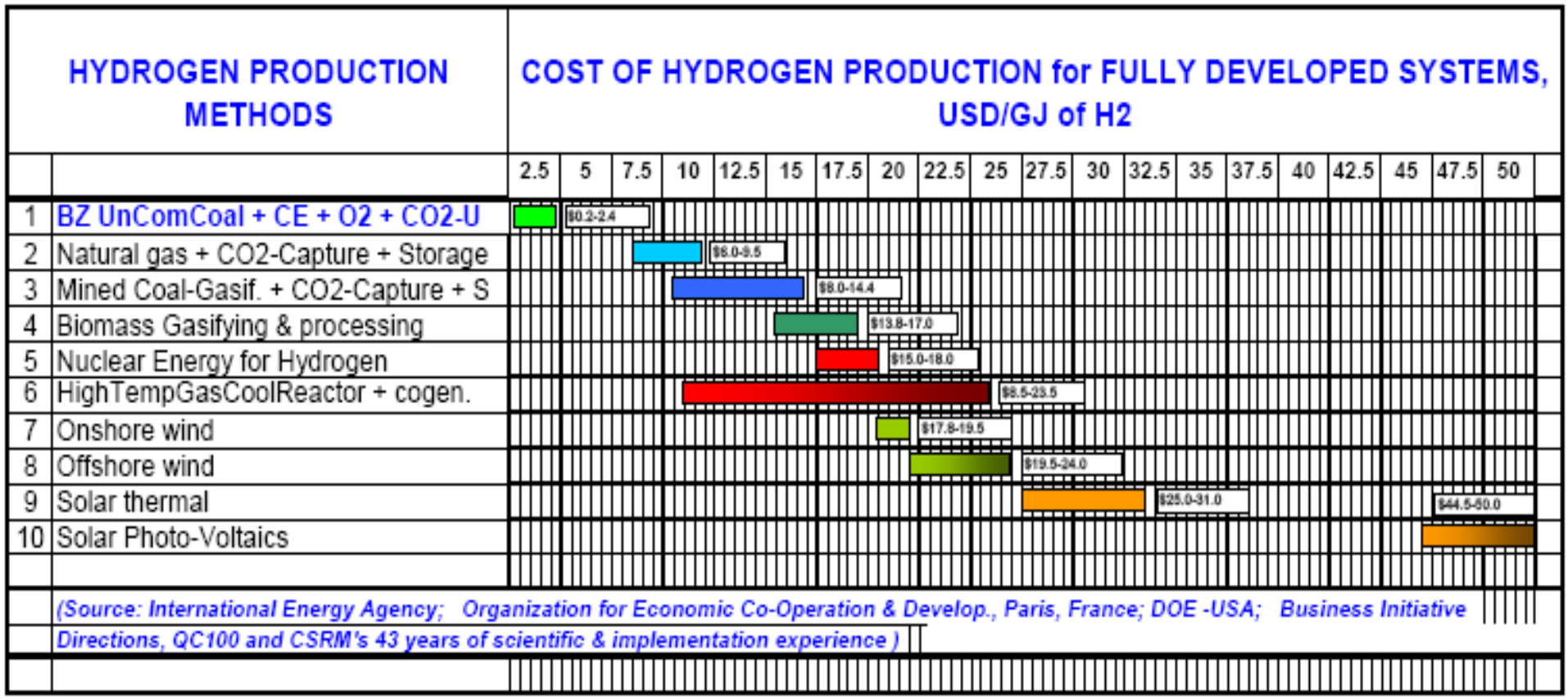
ONE SDS SYSTEM CAPACITY PRODUCTION

- 1 billion m^3 of synthesis gas per year
- 2.190 mln MWh electricity per year

THOSE PRODUCTION REQUIRES

- Coal 1,942,000 tons/y
- Oxygen 540,000 tons/y
- Water 1,540,000 tons/y

COST OF HYDROGEN PRODUCTION



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Conclusions

- **UCG is a potential coal utilisation clean technology receiving interest around the world**

- **UCG provides significant environmental benefits, such as:**
  - **reduction of greenhouse gas emissions**
  - **no surface disposal of ashes, tailings and wastes**
  - **limited rehabilitation**

- **Recently, Poland has begun re-evaluating UCG activities – exploratory studies and field tests**

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QUESTIONS ?