RESEARCH AND ACTIVITIES OF THE CLEAN COAL TECHNOLOGIES CENTRE

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BASIC PROCESSES AND PRODUCTS OF COAL UTILIZATION

- Combustion: heat, power
- Hydrogenation (liquefaction): liquid fuels
- Pyrolysis: chars, liquid hydrocarbons, gas (coking gas, low temperature oven gas)
- Gasification: synthesis gas, fuel gas, synthetic natural gas
Coal gasification technologies may be divided into:

- Surface
- Underground
UTILIZATION OF COAL–DERIVED SYNTHESIS GAS

Energy
- Power
- Heat

SYNGAS
- Ammonia
- Chemicals
- Fuel cells
- Hydrogen
- Methanol
- Ethylene
- Acetic acid
- Formaldehyde
- Dimethyl ether
- Methyl acetate
- Polyolefin
- Gasoline

Liquid fuels (F-T synthesis)
- Naphtha
- Gasoline
- Diesel oil
The **Clean Coal Technologies Center (CCTW)** is a joint venture investment of the Central Mining Institute (GIG) from Katowice and the Institute for Chemical Processing of Coal (IChPW) from Zabrze. The task of the Center is a creation of the leading scientific site for promotion and industrial implementation of clean coal technologies. The investment was financed within the Innovative Economy Operational Programme 2007-2013, Priority 2. R&D Infrastructure, Measure 2.1 Development of high research potential centres.
Modern laboratories equipped with scientific and research equipment, IT hardware and specialized software for interdisciplinary research activities covering:

- rationalization of the production and utilization of energy
- environmental monitoring
- process engineering, nanotechnology and fuel cells
- mitigation of the environmental impact of coal production and utilization
- lifecycle of technologies and products (LCA)
- CO₂ capture, storage and utilization (CCS and CCU)
- determination of physicochemical properties of coal and other solid fuels
- numerical modelling
Pilot scale installations for R&D works in the field of prospective thermochemical technologies of coal processing, including in particular:

- process of **underground**, pressure or non-pressure, **coal gasification** aimed at production of syngas with a high content of hydrogen and of gases for power use,
- **surface gasification** of solid fuels,
- **direct coal liquefaction** process aimed at the production of engine fuels and chemical raw materials,
- processes of **hydrogenation** and **refinement** of coal-derived substances,
- **separation** and **purification** of process gases using membrane techniques and methods of absorption and adsorption, including the pressure swing adsorption - PSA,
- **separation of CO\(_2\)** from process gases
DEVELOPMENT OF UCG IN GIG: RESEARCH PROJECTS

“Elaboration of coal gasification technology for a high efficiency production of fuels and electricity”
2010 - 2015

Funding bodies:
- EU Research Fund for Coal and Steel
- National Centre for Research and Development (NCBiR)
- EU 7th Framework Programme

HUGE
2007 - 2010

HUGE2
2011 - 2014

COGAR
2013 - 2016

TOPS
2013 - 2017

Coal2Gas
2014 - 2017

MEGAPlus
2018 - 2021
RECENT ACTIVITIES OF GIG IN THE UCG TECHNOLOGY:
SUMMARY

- 2 field in-situ UCG trials in Mine Barbara,
- 1 Pilot-scale UCG operation in Mine Wieczorek (60 days),
- 16 large ex-situ experimental simulations of UCG,
- Coordination of 3 large research projects on UCG,
- Participation in 2 other projects as a project partner,
- 28 original research papers in high IF journals dedicated to the conducted research.
Fixed-bed reactor experimental stand with gasification agents pre-heating system

1 – gas inlets,
2 – water pump with a steam generator,
3 – gasification agents pre-heating system,
4 – fixed bed reactor with resistance furnace,
5 – flowmeter and
6 – gas chromatograph Agilent 3000A
Determination fuel’s suitability for use in industrial processes gasification by reactivity parameter.

Reactivity allows to determine which of the PPG coals reacts best with the gasifying agent.

Coal chars reactivity for 50% of carbon conversion, $R_{50}$, and the maximum reactivity, $R_{\text{max}}$
COMPARATIVE ANALYSIS OF SELECTED GASIFICATION TECHNOLOGIES FROM THE PERSPECTIVE OF POLISH MINING GROUP CONDITIONS

The main objective: to identify a technology that is technically, economically and environmentally optimal for implementation on the basis of quantitative and qualitative factors for electricity production.

1. Possibility to gasify low-calorie carbon materials with high ash content and grain diameter <1 mm
2. Flexibility of installation operation expressed in terms of resistance to changes in quality parameters of the coal charge and the size of the feed stream
3. Technological maturity of the offered reactor design
4. Scale of commercial application of the technology
5. Low amount of gasification side products produced (gas tars, oils)

Number of criteria for the assessment of gasification technologies has been implemented.
1. Analyses of **technological parameters** - desk research:

- technological maturity,
- scale of commercial use,
- flexibility of installation operation
- possibility of gasification of materials of low quality (high ash content, low calorific value).
2. **Economic** analyses - CAPEX, OPEX, DGC (Dynamic Generation Cost):
   - Investment outlays,
   - Operating costs,
   - Dynamic unit cost.

\[
DGC = \sum_{t=0}^{n} \frac{KI_t + KE_t}{(1 + i)^t} - \sum_{t=0}^{n} \frac{EE_t}{(1 + i)^t}
\]

<table>
<thead>
<tr>
<th>Description</th>
<th>CoP E-Gas</th>
<th>SES</th>
<th>Shell Gasification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital expenditure CAPEX [PLN]</td>
<td>4 847 981 491</td>
<td>4 355 062 400</td>
<td>5 077 787 581</td>
</tr>
<tr>
<td>Operating costs OPEX [PLN]</td>
<td>1 582 856 268</td>
<td>1 202 421 372</td>
<td>1 502 589 097</td>
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</table>

**Gasification technology**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>CoeCoPhilips</th>
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<th>Shell</th>
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</thead>
<tbody>
<tr>
<td>Total discounted costs</td>
<td>PLN</td>
<td>16 619 687 274</td>
<td>12 414 048 074</td>
<td>16 252 542 696</td>
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<tr>
<td>Discounted sum of the amount of electricity produced</td>
<td>MWh</td>
<td>31 531 690</td>
<td>32 834 652</td>
<td>29 863 896</td>
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</tbody>
</table>
3. **Environmental** analyses - LCA, carbon footprint:
   - assessment of the environmental impact of the gasification technology.
   - use of SimaPro software with Ecoinvent 3 database
4. Analyses **supporting** the decision making process – Multicriteria Analysis.

**APPLIED METHODS OF ANALYSIS**

![Possibility of application in different places](Possibility_of_application.png)

![Scale of commercial use](Scale_of_commercial_use.png)

![Possibility of purification of low quality materials](Possibility_of_purification.png)

![Flexible operation of the system](Flexible_operation_of_the_system.png)

### Analyses supporting the decision making process – Multicriteria Analysis

#### Summary

- **Objective 1 – Freight delays:**
  - ConocoPhillips E-Gas: 0
  - SES: 0
  - Shell: 0

- **Objective 2 – FT Feed latera:**
  - ConocoPhillips E-Gas: 0
  - SES: 0
  - Shell: 0

- **Objective 3 – Reduced freight on road:**
  - ConocoPhillips E-Gas: 0
  - SES: 0
  - Shell: 0

- **Possibility:**
  - ConocoPhillips E-Gas: 0
  - SES: 0
  - Shell: 0

- **Public & Technical:**
  - ConocoPhillips E-Gas: 0
  - SES: 0
  - Shell: 0

- **Social, Social and Environmental Effects:**
  - ConocoPhillips E-Gas: 0
  - SES: 0
  - Shell: 0

#### Weighting of Objectives

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<tr>
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#### Scoring

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**Risk Assessment**

- **Risk:**
  - ConocoPhillips E-Gas: 0.5
  - SES: 0.5
  - Shell: 0.5

**Sensitivity Score**

- **Objective 1 – Freight Delays:**
  - ConocoPhillips E-Gas: 2
  - SES: 2
  - Shell: 2

- **Objective 2 – FT Feed latera:**
  - ConocoPhillips E-Gas: 2
  - SES: 2
  - Shell: 2

- **Objective 3 – Reduced freight on road:**
  - ConocoPhillips E-Gas: 2
  - SES: 2
  - Shell: 2

**Risk:**

- ConocoPhillips E-Gas: 2
- SES: 2
- Shell: 2

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**Scoring**

- ConocoPhillips E-Gas: 0.5
- SES: 0.5
- Shell: 0.5

**Risk:**

- ConocoPhillips E-Gas: 2
- SES: 2
- Shell: 2
SUMMARY

The conducted analysis showed the potential for coal gasification based on PGG coal resources and indictated the **fluidized-bed gasification system** as a technology with the highest rate in all criteria covered by the analysis.
Thank you for your attention