Coal gasification in Poland - perspectives and key driving forces

Aleksander Sobolewski and Tomasz Chmielniak

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Scope of presentation

1. Energy balance of Poland: coal vs. natural gas
2. Coal gasification
   - Technology overview
   - IChPW - gasification R&D in Poland
3. Strategy for coal gasification development in Poland
5. Gasification economy and profitability
6. Gasification vs. EU environmental policy
7. Conclusions
Background: Poland 2016

1. Population: 38 million
2. History: Coal-based economy
3. 85% of electricity from coal
4. A lot of old coal-fired power plants
5. Excellent R&D coal processing
6. European environmental protection regulations

7. Coal overproduction: 8 MTPY
   - Export?
   - Shut down of some coal mines?
   - Alternative usage of coal!
“The role of carbon energy sector in Poland must be seen as an opportunity for our country to be the European leader in the development of clean coal technologies.”


“(…) Coal gasification seems to be very promising type of clean coal technology.”

The energy balance of Poland

Conclusions from the analysis for Polish Energy Policy until 2050; Annex 2.: the Polish Energy Policy until 2050; The project version 02.

Power generation

The balance of primary energy

2012 - 51%
2050 - 30%

bituminous coal
lignite coal
natural gas
RSE
nuclear energy
other

Conclusions from the analysis for Polish Energy Policy until 2050; Annex 2.: the Polish Energy Policy until 2050; The project version 02.
Natural gas sources for Polish economy

REPORT ON THE RESULTS OF MONITORING GAS FUEL SUPPLY SECURITY from the period from 1 January 2014 till 31 December 2014. The Ministry of Economy 2015

The forecast on the basis of the Polish Energy Policy until 2050 and taking into account LNG terminal (amount of gas production and import from Germany and the Czech Republic as in 2014), Coal gasification: 1 million t/year.
Coal gasification technology: Advantages

- Zero emission power generation – CCS/current CCU model
- Substitution liquid and gaseous fuel – chemical synthesis
- Polygeneration systems (chemical and energy)

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Coal gasification technology: Commercial technology suppliers

- Entrained flow technologies
  - Water slurry and dry feeding
- Fluidized bed technologies
- Fixed bed technologies

- East China University of Science and Technology (OMB: Opposed Multi-Burner Gasifier)
- Northwest Research Institute (MCSG: The Multi-Component Slurry Reactor)
- Aerospace Science and Technology Corporation (HT-L: Pressurized, Down-Flow, Entrained Reactor)
- Institute of Coal Chemistry (AFB: Ash Agglomerated, Fluidized-Bed Reactor)

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Coal gasification technology: State of business

Coal gasification:
- 25% of global ammonia production
- 30% of global methanol production

Production directions – example of China

- Methanol: 67; 37%
- Ammonia: 68; 37%
- Other: 46; 26%
- Gas fuels: 12; 7%
- Liquide fuels: 10; 5%
- Electricity: 3; 2%
- Other: 21; 12%
Institute for Chemical Processing of Coal

- Establishment: 1955
- Supervision: Polish Ministry of Energy
- Employment: 180 people

Zabrze (Poland)
Clean Coal Technology Center

The technical media store area

Technological Building I (PDU scale installation and testing plants)

By-products station

Coal preparation station

Coal storage yard

Technological Building II (bench scale sets and testing plants)

Workshop

Zabrze

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Clean Coal Technology Center (technological building no 1)
Coal gasification: R&D in Poland: 40 years of IChPW experience

RESEARCHES
- Gaining of knowledge and experience
- No attention to process economy

MARKET
- Cooperation with industrial partners
- Feasibility studies and novel technologies implementation

PS: "Advanced technologies for energy production"
PBZ: "Chemistry of coal"
CLEAN COAL TECHNOLOGIES CENTRE

FIRST GAS COOLING AND CLEANING SYSTEMS
- Gasisication of biomass and wastes
  EKOD, 5 MW
- Biomass gasification, GAZELA, 25 kg/h
- Coal gasification, CFB reactor, 200 kg/h
- Pressurized reactor CFB, 125 kg/h; 1.6 MPa

ADVANCED GAS COOLING AND CLEANING SYSTEMS DEVELOPMENT
- Modelling and numerical simulations
- Gasification of biomass and wastes
  EKOD, 5 MW
- CONBIOT Excellence centre
- Accreditation of four laboratories

MULTIFUNCTIONAL REACTOR BFB, 50 kg/h
- TANDEM, 35 kg/h
- CROSS-ACTIV, 100 kg/h
- IPPS/CFB, 300 kg/h
- Smokeless fuels, 8000 kg/h

1975

Government Programme PR1
- "Complex processing of coal"
Alfred Krupp von Bohlen und Halbach Foundation
- "Coal processing centre"

5 PR: "Wastewater study/gasification"
PS: "Advanced technologies for energy production"

Multifunctional reactor BFB, 50 kg/h
BFB cold model, ø350 mm
CFB cold model, ø250 mm

Smokeless fuels, 8000 kg/h

CONBIOT

PS: "Advanced technologies for energy production"
Substitution of natural gas

- To meet the needs of domestic nitrogen plants (2,5 billions m³ of natural gas) 7 – 8 millions tons of coal must be gasified (depending on the fuel quality and gasification technology)

- To produce 500 000 t/year of methanol about 1 million tons of coal is needed, what is equivalent of approx. 400 million m³ of natural gas consumption.
Strategy for coal gasification development in Poland

Short term activities beyond 2020
- Development of industrial scale plant based on selected commercial available technology

Medium and long term activities beyond 2030
- Development of industrial scale plant based on Polish national gasification technology in CFB reactor (Demo stage necessary !!)
Strategy for coal gasification development in Poland

The first in EC full commercial scale coal gasification plant oriented for chemicals

Scale: 1 Mt of coal/year

What is necessary?

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Actions taken in Poland 2015/2016

Consortium:
Grupa Azoty SA, TAURON SA, KGHM SA

Feasibility Study of Polygeneration Plant

- Complete Feasibility Study for different chemical production systems integrated with coal gasification.
- Location: Grupa Azoty, Zakłady Azotowe Kędzierzyn S.A.
- Contractor: Amec Foster Wheeler Italiana
Economic analysis – assumptions (Poland 2015/16)

Coal:
- 2 bituminous coal from Poland
- LHV: 20 – 24 MJ/kg

Entrained flow reactor
- One reactor (1000 K t/y)

Brown field investment
- In existing chemical plant

Products: ammonia / methanol

4 technological options:
1) ammonia - new line
2) ammonia - extended line
3) ammonia - extended line 2
4) methanol

<table>
<thead>
<tr>
<th>Option</th>
<th>(TPC) [kEuro]</th>
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<tbody>
<tr>
<td>ammonia 1)</td>
<td>490 600</td>
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<tr>
<td>ammonia 2)</td>
<td>486 400</td>
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<tr>
<td>ammonia 3)</td>
<td>480 500</td>
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<td>methanol 4)</td>
<td>593 300</td>
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Economic analysis – assumptions (Poland 2015/16)

Ammonia new line:

Coal consumption:
- coal A – 81.0 t/h
- coal B – 66.3 t/h

Ammonia production:
- 1200 t/day
- 394 200 t/y
### Economic analysis – assumptions (Poland 2015/16)

#### Coal „A”
(20 MJ/kg)

#### Coal „B”
(24 MJ/kg)

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<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
<th>Min/Max</th>
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<tbody>
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<td>%wt</td>
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<tr>
<td>H</td>
<td>%wt</td>
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<td>N</td>
<td>%wt</td>
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<tr>
<td>S</td>
<td>%wt</td>
<td>1.1</td>
<td>0.8 – 1.7</td>
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<tr>
<td>O</td>
<td>%wt</td>
<td>10.1</td>
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<tr>
<td>Cl</td>
<td>%wt</td>
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<td>0.13 – 0.45</td>
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<tr>
<td>Ash</td>
<td>%wt</td>
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<tr>
<td>LHV (calculated)</td>
<td>kJ/kg</td>
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<td>HHV (calculated)</td>
<td>kJ/kg</td>
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<tr>
<td>H</td>
<td>%wt</td>
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<td>N</td>
<td>%wt</td>
<td>1.0</td>
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<tr>
<td>S</td>
<td>%wt</td>
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<td>O</td>
<td>%wt</td>
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<tr>
<td>Cl</td>
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<tr>
<td>Ash</td>
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<td>HHV (calculated)</td>
<td>kJ/kg</td>
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Economic analysis – assumptions (Poland 2015/16)

Coal cost (2016-2026):

- Variant 1: Expensive bituminous Polish coal “B” 2,71 – 3,73 € /GJ
- Variant 2: Cheap bituminous Polish coal “A” 2,24 – 2,80 € /GJ

Sales prices of the products:

- Ammonia: Variant 2: 366 – 440 € /t
- Methanol: Variant 2: 410 – 469 € /t

(average methanol market price
2014-2015: 363 € /t; max: 450 € /t)
Economic analysis—results (1)

<table>
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<tr>
<th>Option</th>
<th>Product</th>
<th>IRR</th>
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<tr>
<td>1</td>
<td>Amoniak</td>
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<tr>
<td>2</td>
<td>Amoniak</td>
<td>10.77</td>
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<tr>
<td>3</td>
<td>Amoniak</td>
<td>8.77</td>
</tr>
<tr>
<td>4</td>
<td>Metanol</td>
<td>13.53</td>
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<table>
<thead>
<tr>
<th>Fuel</th>
<th>FCFF/7.95/Variant 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.95</td>
</tr>
<tr>
<td>B</td>
<td></td>
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</tbody>
</table>
Economic analysis – results (2)

- Option 1 – new ammonia line 1200 t/d
- Investment Grant – up to 100 M€uro
Economic analysis—results (3)

- Option 1 – new ammonia line 1200 t/d
- Coal price – reduction up to 20%

Option I - IRR FCFF Method (Coal price Sensitivity)

- 7.95
Economic analysis – results (4)

- Option 1 – new ammonia line 1200 t/d
- Ammonia price: -30% to +30%

**Option 1 - IRR FCFF Method (Ammonia price sensitivity)**

- Ammonia price: -30% to +30%
- Ref Case

![Graph showing IRR sensitivity analysis](image)
Economic analysis – conclusions:

It looks good
– for the first moment only.

- The price of coal is critical. Coal in Europe is too expensive. Expectation: 1 Euro/GJ vs real market price: 2.5 Euro/GJ
- Gasification business is very sensitive for final products prices
- High CAPEX – cheaper technology is needed!

Why not ECUST??
Key question:

Why is so difficult to start up coal gasification in EU?

- Not stable market prices for coal, natural gas and chemicals

- Not enough profitable business & high risk. Expected banks payback rate (official) IRR=10—15%, businessman expectation (unofficial) IRR>20%!!

- Decarbonisation Policy of European Commission

- Restrictive environmental protection regulations
EU “Sustainable Development” concept:

- Nice idea: especially during election campaign
- Real problem: especially for heavy industry

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EU “Sustainable Development” concept:

European Union in XXI century?

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Summary

Poland is ready to take the strategic decision about construction and start-up the first industrial coal gasification plant...beyond standards!
Summary

Key driving forces:

- availability and quality of coal
- lack of natural gas
- well-known technology
- educated staff and R&D
- negative trade balance for chemicals

....and

We are still waiting!
Thank you for your attention!