Clean Coal Technology – R&D program

Jarosław Zuwała

Contents

1. Profile of the Institute for Chemical Processing of Coal
2. Poland – country of coal based energy
3. Clean Coal R&D Programs
4. Centre for Clean Coal Technologies in Zabrze
5. Cooperation with DOE/NETL
6. Conclusions

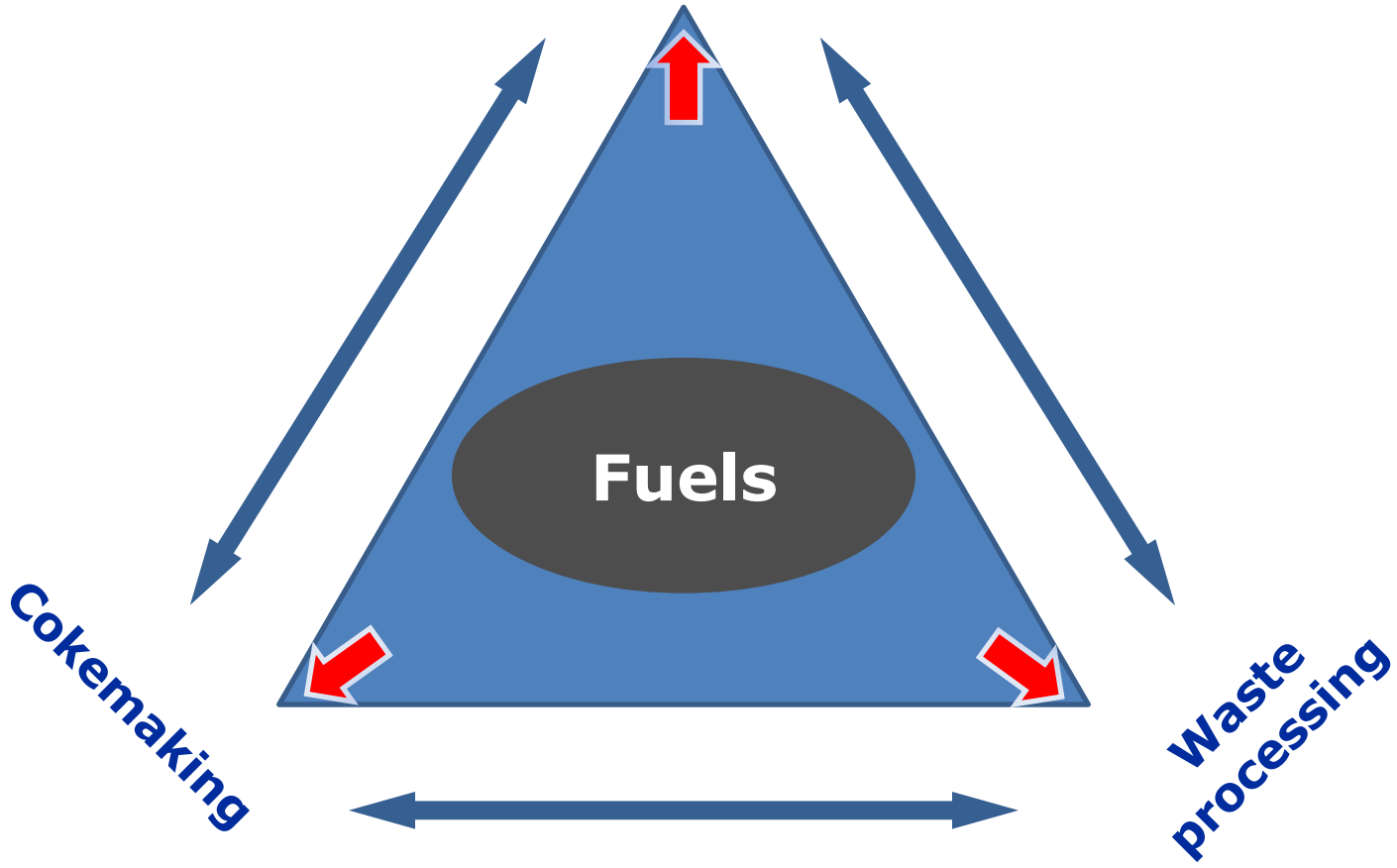
MISSION STATEMENT

To deliver the innovative knowledge strengthening the competitiveness of industry, particularly: oil and gas processing, pyrolysis of coal, **low-emission energy generation from coal** and biomass, and waste processing sectors.

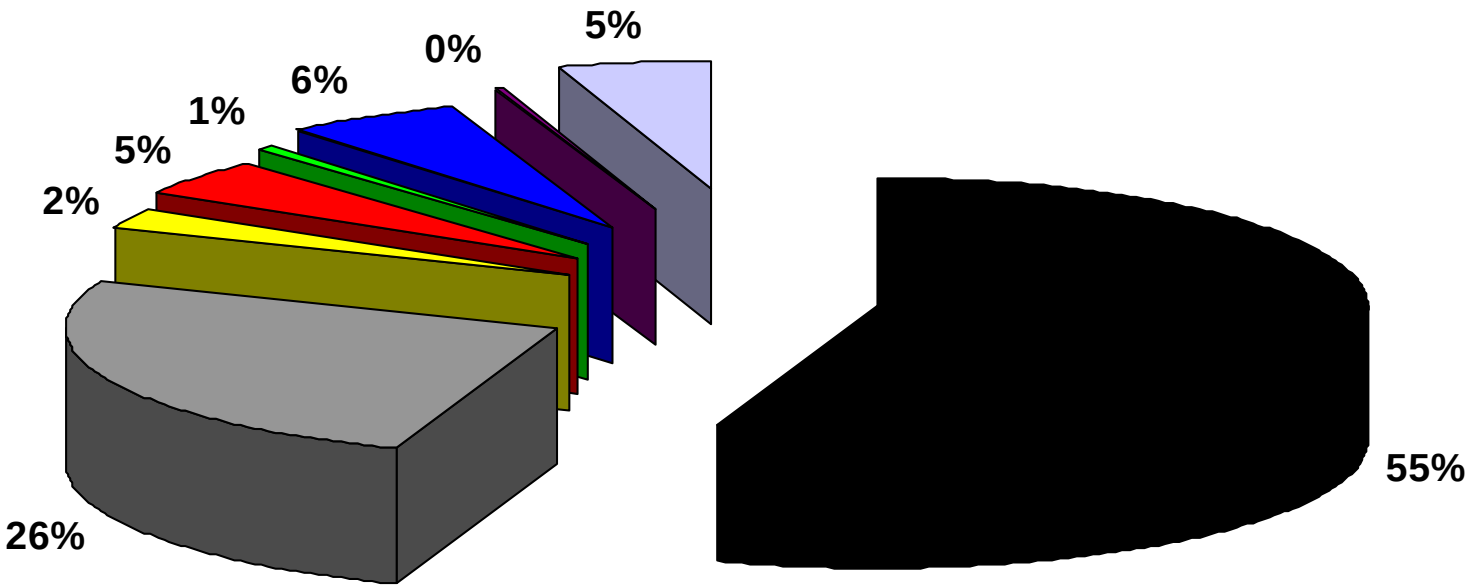
VISION STATEMENT

The Institute is striving to achieve a leading position as a centre of technological innovations creation, having competent and highly qualified staff capable of competing on the European markets in the fields of fuels thermal processing and raw materials and products properties.

Heat & power production



Installed output of Polish electricity utlities



80% of installed power is coal based !

Polish coal/energy facts

1. Polish production of coal for energy: 11 mln Mg, coking coal: 2 mln Mg (2012).
2. In 2011 hard coal and lignite based electricity production amounted to 89% of the total electricity production. According to „Polish Energy Policy to 2030" share of coal based net electricity should reach 88% in 2010 and 82% in 2015.
3. Lignite fired utilities offer cheaper electricity comparing to hard coal fired units (lower production costs, also because of technological and capital integration with power plants), although the investment costs are higher.
4. Electricity consumption in Feb, 13 **decreased almost by 10%** comparing to Feb, 12.
5. In Polish conditions, according to the simulations done in ICPC, only at the price level of abt. 55 EUR/Mg CO2, total cost of lignite based electricity would equal to the total cost of hard coal based electricity.
6. Polish hard coal reserves at the end of 2012 amounted to 8.4 mln Mg.
7. What then will be the future of coal…..clean coal technologies? production of chemicals and fuels?

National Center for Research and Development **(NCBiR) is a state owned unit created for realization of Polish national scientific and innovative policy.**

Mission: support of Polish scientific units and companies for developing their ability to produce and use solutions based on the results of scientific research to provide economic development and for the benefit of society.

Program of Strategic Projects is resulting from the scientific and innovative policy of Poland, serving the development of the Polish economy and the public sector.

1-st call for Strategic Projects (September 2009): „Advanced techniques for energy generation"

Task No.1:

„Development of technologies for high-efficiency zero-emission coal-fired boilers integrated with CCS units"

Duration: **60 months,** budget: **70 M PLN (22 M USD)**

Task No.2:

„Development of oxy-combustion technology for pulverized and fluidized bed boiler integrated with CCS"

Duration: **60 months,** budget: **80 M PLN (25 M USD)**

Task No.3:

„Development of coal gasification technology for highly efficient production of fuels and electricity"

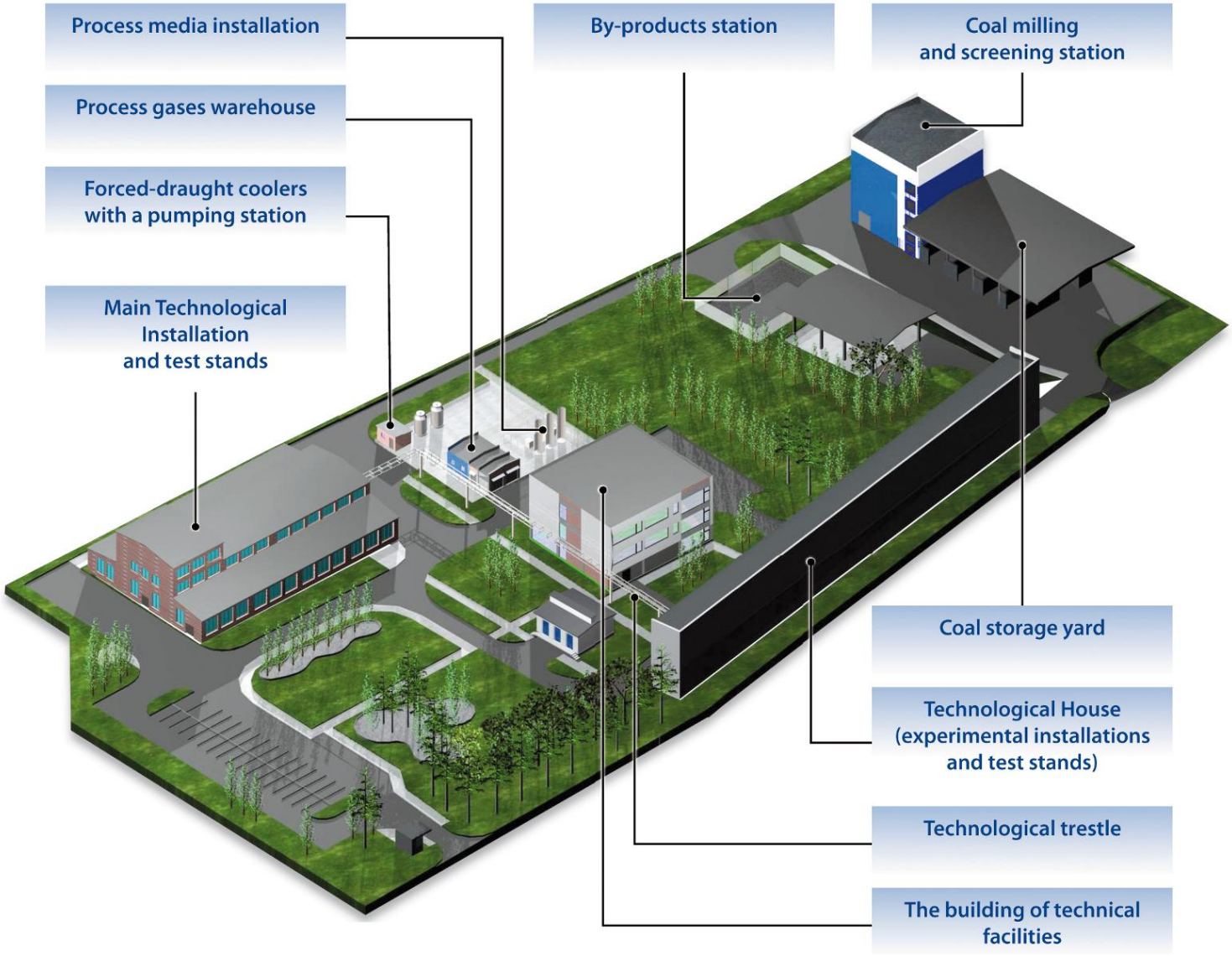
Duration: **60 months,** budget: **80 M PLN (25 M USD)**

Task No.4:

„Development of integrated technology of fuels and energy production from biomass, agricultural waste and other"

Duration: **60 months,** budget: **70 M PLN (22 M USD)**

Clean Coal Technology Center – unique infrastructure in Zabrze



Just commisioned!

CCT
CENTRUM CZYSTYCH TECHNOLOGII WĘGLOWYCH
GIG

Scaling-up CO2 capture technology:

No.							
1							
2							
3	**Installation for CO_2 capture process testing**	20-100					
4	**The Mobile Pilot Plant**	200	DN-300 H - 14 m	TAURON Wytwarzanie S.A.	Start up	2013.03	

Semi technical installation for CO2 capture process testing 20-100 m3n/h – (ICPC)

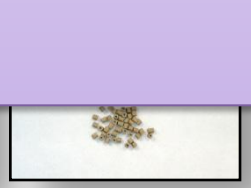
Specification:

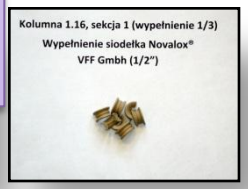
Solution flow: up to 750 dm^3/h
Gas flow: 20-100 m^3_n/h
Examined gas: real gas mixtures
Work regime: short continuous tests (absorption-desorption)
Columns diameter: 265 mm
Columns height: 7,0 m
Desulphurisation: Solid adsorbent
Device count: 34

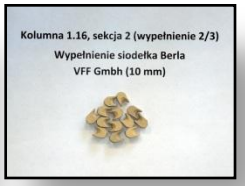
Control System:

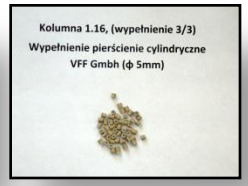
Measurements: approx. 130 analogs
Online gas analysis: Ultramat 23 analyzers
Solution analysis: Ion chromatograph

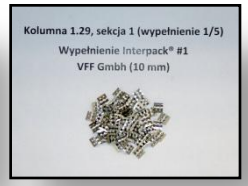
The first test using flue gas was conducted on 12.12.2013

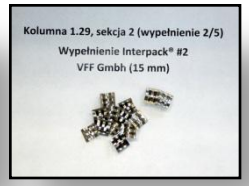








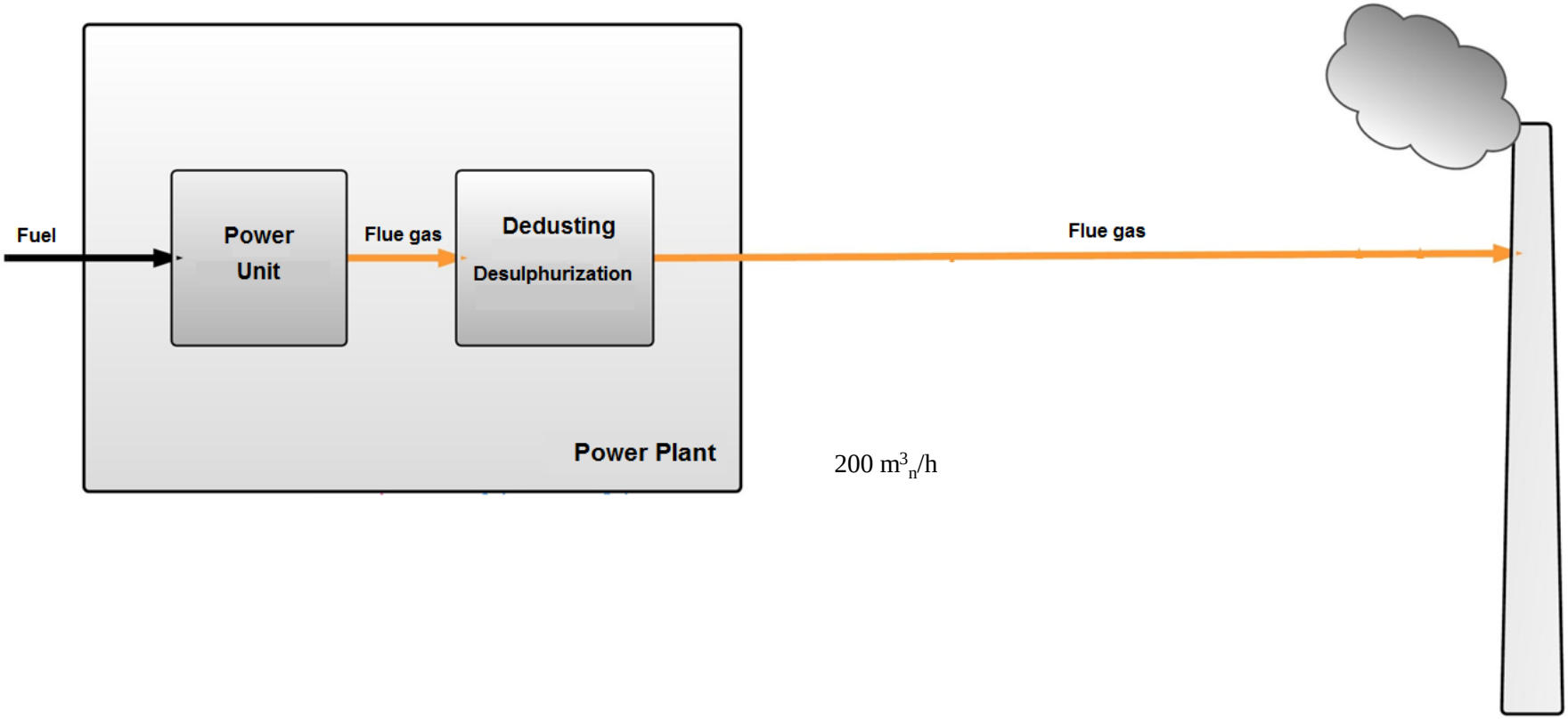




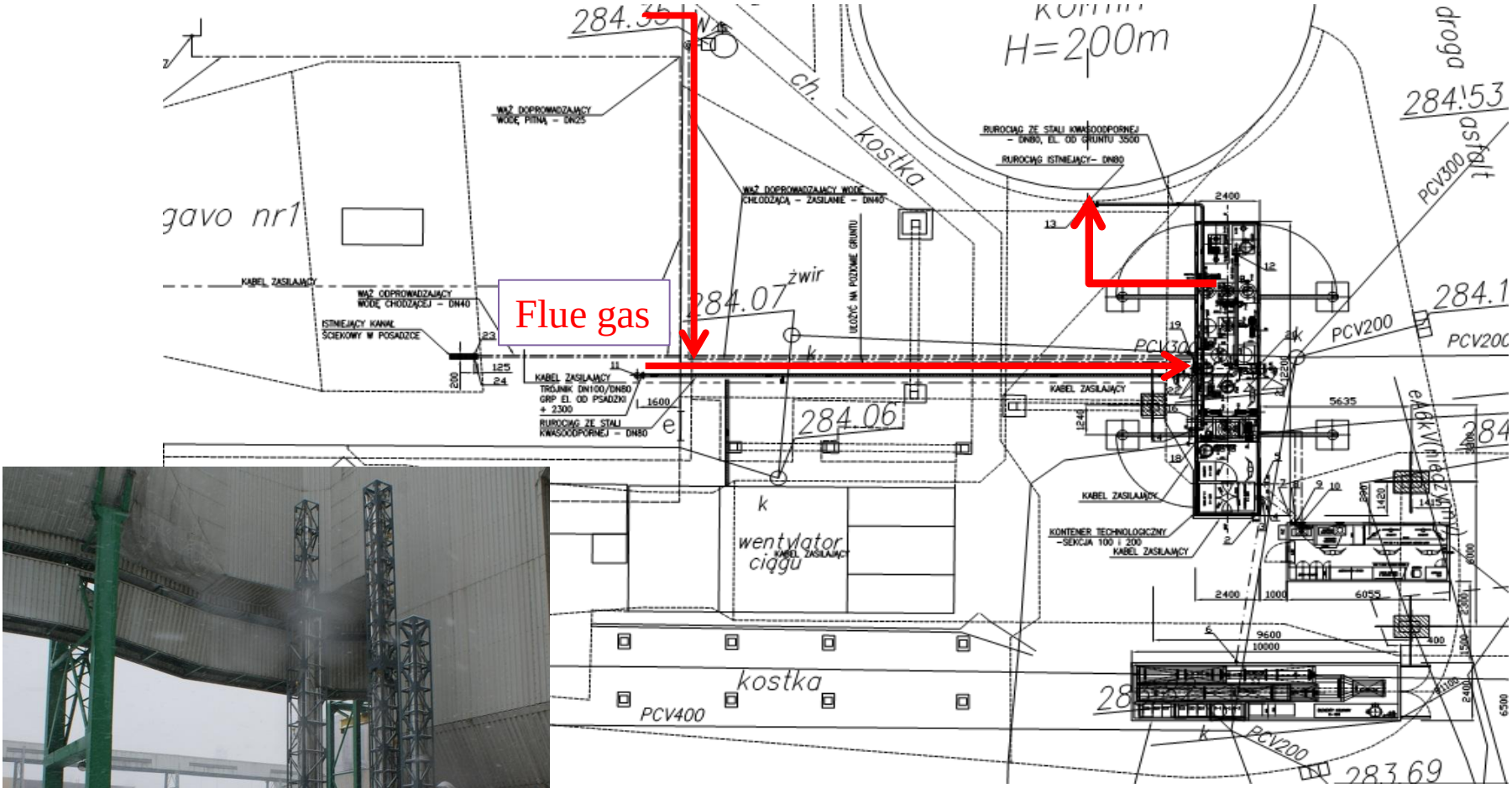
The Mobile Pilot Plant – ICPC and TAURON cooperation

Column diameter:	300 mm
Absorber height:	14,0 m
Desrober height:	15,0 m
Number of apparatus:	40
Measuring points:	about 180 points

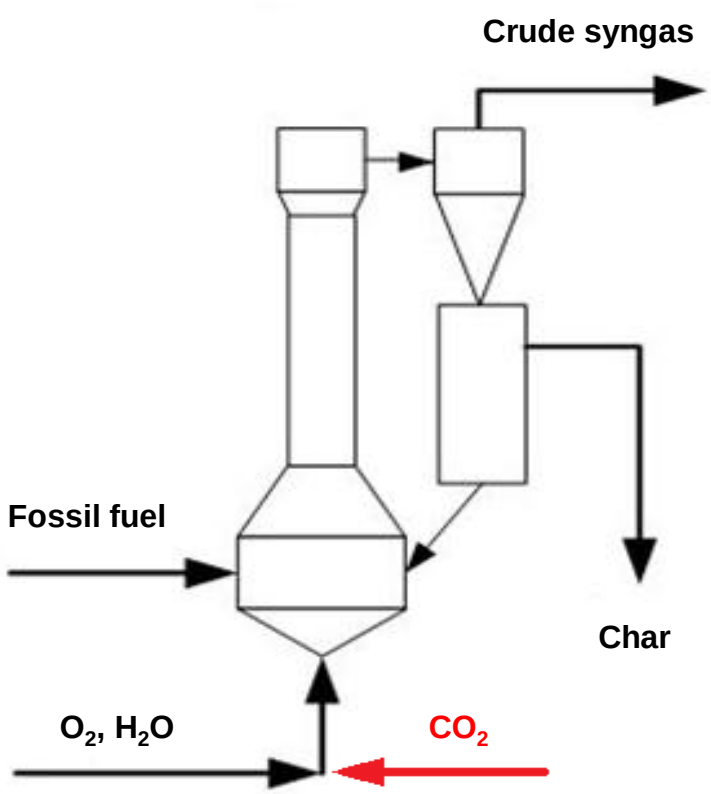
The Mobile Pilot Plant - connection to the power plant infrastructure



The Mobile Pilot Plant location– Łaziska Power Plant



Circulating fluidized bed reactor



$C + CO_2$	$\leftrightarrow 2CO$	+ 172 kJ/mol
$C + O_2$	$\rightarrow CO_2$	- 396 kJ/mol
$C + H_2O$	$\leftrightarrow CO + H_2$	+ 131 kJ/mol
$C + ½O_2$	$\rightarrow CO$	- 110 kJ/mol

Effects:

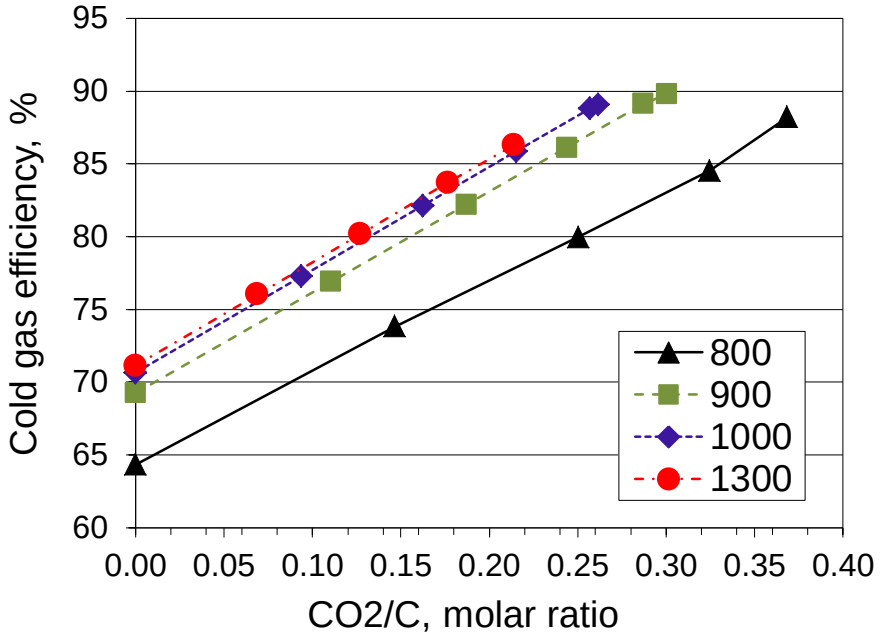
- **utilization of CO_2 removed from fossil fuels conversion,**
- **increase of process yield and improvement of syngas synthesis economy,**
- **reduction of fossil fuels consumption in syngas production,**
- **decrease of oxygen consumption (CO_2 as oxidation agent).**

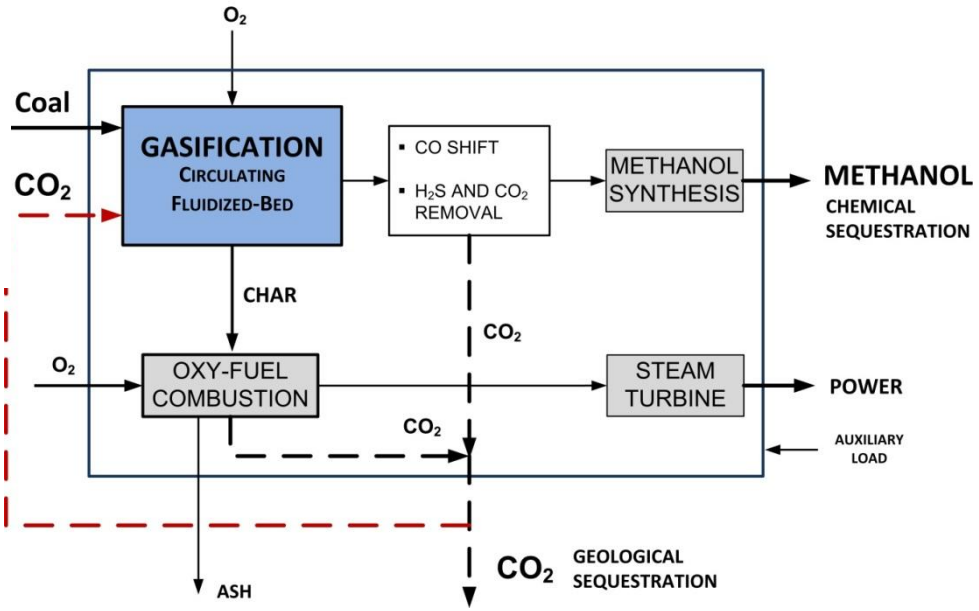
Use of CO2 in coal gasification as a co-gasifing agent – first trials

First technological test
(trial @ 130 kg/h coal, max. 200 kg/h)
Gas composition: 50% CO2, 50% O2
Ambient pressure

Coal gasification & Oxy-combustion demo installation located in ICPC (pressure conditions).

Thermodynamic modeling – integration with oxy-combustion

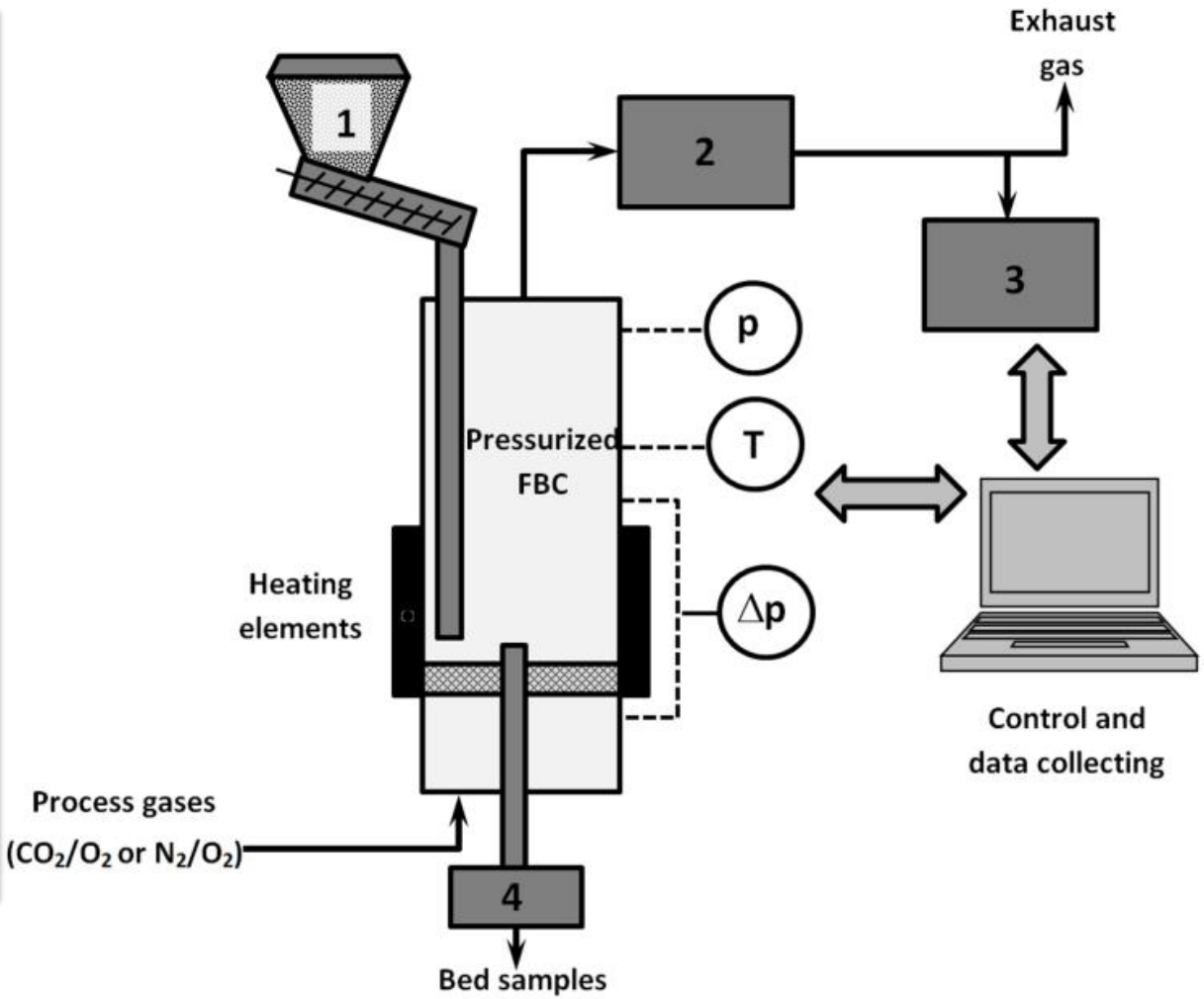




Research group	Unit
Pressurized oxy-fuel combustion	
University of Nevada (USA)/ ThermoEnergy Power Systems (USA) /CANMET (Canada)	(15 MWe), coal/biomass), up to 89,6 bar
Enel Ingegneria e Innovazione (Italy)	5 MWt, up to 4 bar
Institute for Chemical Processing of Coal, Zabrze (Poland)	**Laboratory scale (3 kg of coal/h) and pilot scale, up to 10 bar**
Pressurized oxy-fuel gasification	
Department of Chemical Engineering, Imperial College London	Laboratory scale, up to T=1000°C and p=30 bar
New Power Generation Technology Center of Thermal Power Research Institute of China	Feed up to 16 kg/h, up to p=30 bar, T=1360-1400°C

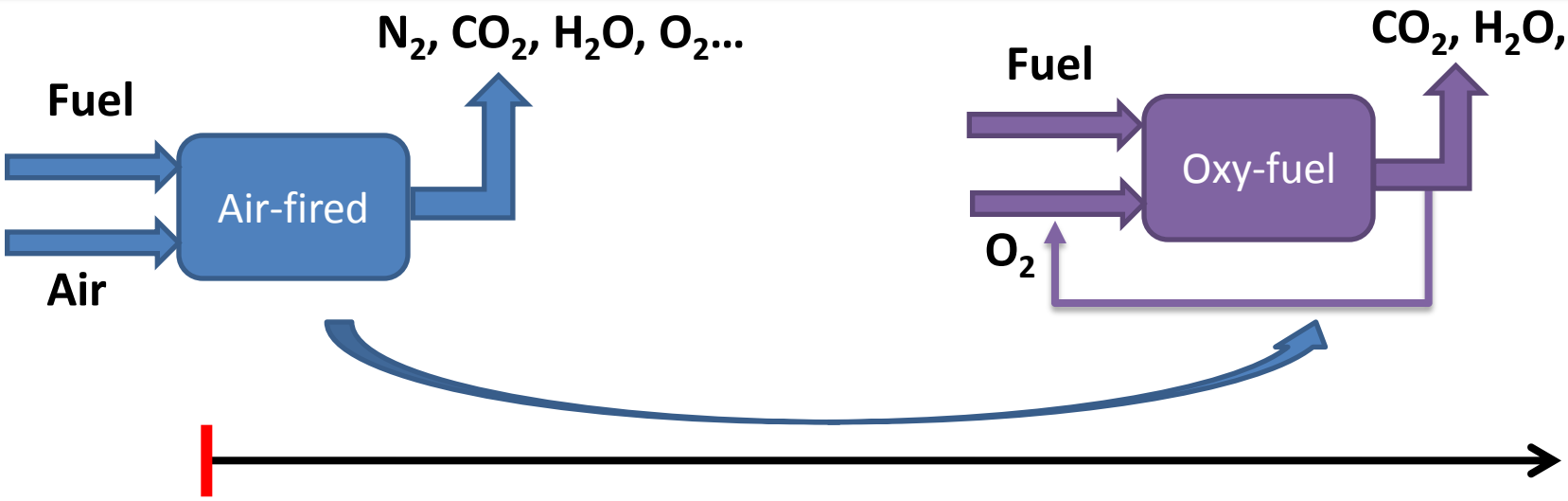
A simplified scheme of the experimental setup

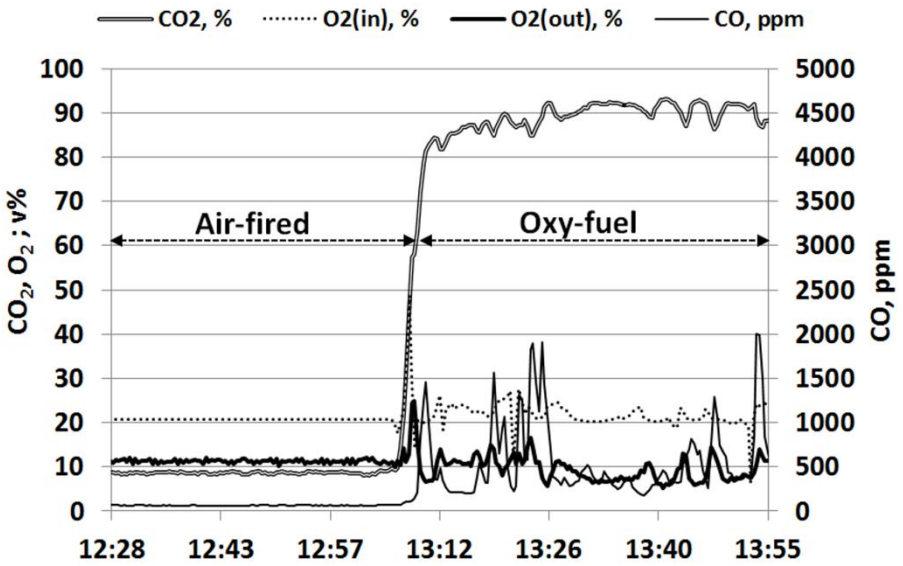
Reactor:
diameter 0.075m,
height 1m,
bed height 0.25m
fuel tank capacity 0.004 m^3
Exhaust gas analysis:
FTIR analyzer (GASMET DX4000)
O_2 analyzers:
paramagnetic (Oxymat 61) and
zirconium sensor (AMS Analysen)
Experimental conditions:
T=750-900°C
p= 1-4.5 bar
Δp= 10-16 mbar
O_2=20-30 vol.%
CO_2=70-80 vol.%
Fuel input: 0.4-1.34 kg/h

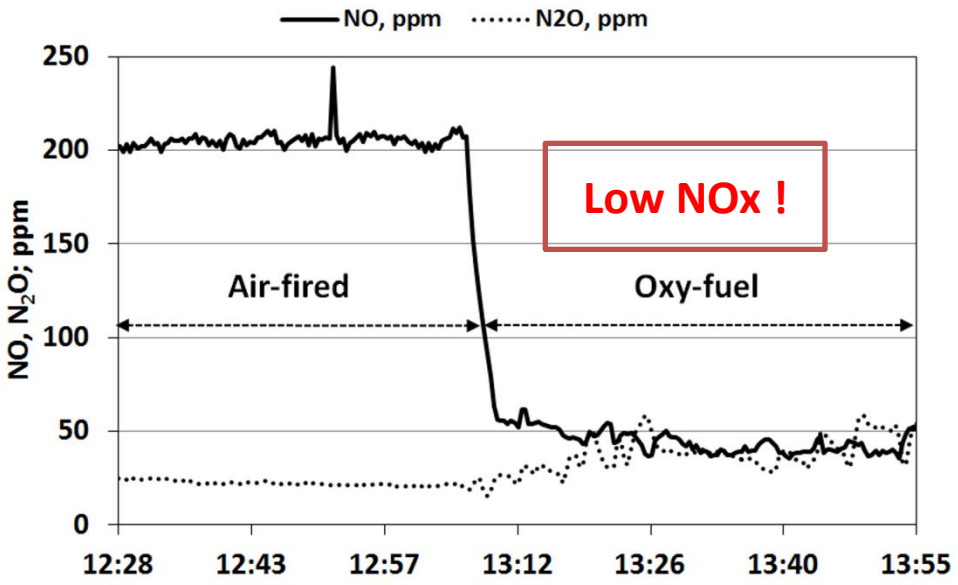


1- pressurized fuel tank, 2- decompression, cooling and cleaning module, 3- gas analyzers, 4- decompression

1. PRESSURIZED OXY-FUEL, Flexi-Burn ™ test, FIRST TIME UNDER HIGHER PRESSURE (2.4 bar, „Ziemowit" coal)

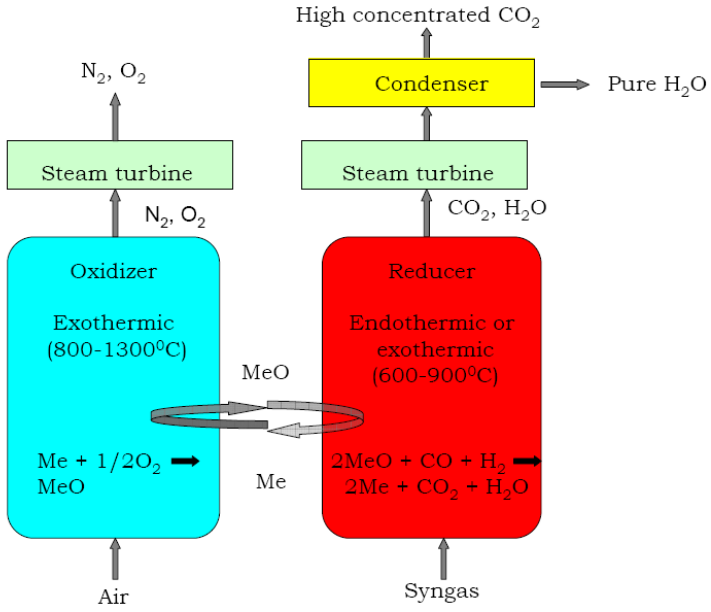






National Energy Technology Laboratory, United States Departament of Energy

§ Obtaining new oxygen carrier
§ Reactivity study (TGA, MS, flow reactor)
§ Material characteristics by XRD, PSD, SEM



University of Utah
§ Cu oxygen carriers preparation

Projects ongoing:

§ Study of combustion and gasification process in chemical looping, 2010-2013
§ Center of Clean Coal Technologies (CCTW) - 7kW CLC installation, methane - fuel

MEMORANDUM OF UNDERSTANDING FOR COOPERATION IN THE AREA OF FOSSIL FUELS BETWEEN

THE U.S. DEPARTMENT OF ENERGY NATIONAL ENERGY TECHNOLOGY LABORATORY

AND

POLAND'S CENTRAL MINING INSTITUTE

AND

POLAND'S INSTITUTE FOR CHEMICAL PROCESSING OF COAL

I. PURPOSE

This Memorandum of Understanding (MOU) reflects a mutual interest on the part of the U.S. Department of Energy's National Energy Technology Laboratory (NETL) and the Główny Instytut Górnictwa (GIG, hereafter known as the Central Mining Institute, CMI) and Instytut Chemicznej Przeróbki Węgla (IChPW, hereafter known as the Institute for Chemical Processing of Coal, ICPC) of Poland to pursue collaborative work to advance the technical, environmental, and cost performance of fossil energy technologies.

II. AREAS OF COOPERATION

Cooperative activities may include, but are not limited to, research on base and enabling technologies and assessments of technology options and economics. Cooperative topics may include:

a) Gasification
b) Carbon management, especially storage technologies
c) Chemical looping
d) Oxy-Combustion
e) Multi-phase flow processes, including fluidization

Other areas of cooperation may be added by mutual written agreement of each Party's Lead Coordinator.

III. FORMS OF COOPERATION

Specific cooperative projects will be defined in supplemental agreements between the Parties. Cooperation may include:

a. Exchange of information, publications, reports, technical data, samples, materials, and instruments.

b. Exchange of scientists, engineers and other specialists for participation in training, project definition activities, research, and technology transfer. Each Party agrees to abide by the other's safety and security requirements.

c. Jointly funded research and development activities in which NETL, CMI, and ICPC share the cost of performance.

V. LEAD COORDINATOR

Each Party shall designate a Lead Coordinator who shall serve as that Party's principle representative for activities under this MOU.

VI. FINANCIAL COMMITMENTS

NETL's commitments in furtherance of this MOU are contingent on the availability of funds appropriated by the Congress of the United States. CMI's and ICPC's commitments in furtherance of this MOU are contingent on the availability of funds to pursue collaborative activities. Unless otherwise agreed by the Parties, each Party shall be responsible for its own costs incurred in furtherance of this MOU.

VII. INTELLECTUAL PROPERTY

Each Party will retain rights to its own background intellectual property. The allocation of rights to newly generated intellectual property will be determined on a project-by-project basis.

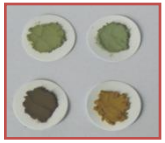
VIII. EFFECTIVE DATE, AMENDMENT AND TERMINATION

This MOU is effective upon the date of the last signature by the Parties and shall remain effective for a 5-year period unless terminated in accordance with the terms set forth herein. The MOU may be modified by mutual consent of the Parties.

Either Party may terminate this MOU by providing written notice to the other Party at least 90 calendar days in advance.

- ✓ 100 different new oxygen carriers of lower manufacture cost were obtained,
- ✓ **Six patent applications**, two patents awarded
- ✓ Grants awarded by**:**
  - Polish Ministry of Higher Education & Science (CCTW, PBZ-MI
  - **U.S. D.O.E.**
  - Polish Ministry Of Affairs & Partners Poland Foundation
  - **British Embassy**

- ✓ New both national and international agreements for cooperation in the field of CLC/CLG are proceed.
- ✓ Selling produced oxygen carriers to University of Utah
- ✓ Exchange of knowledge, exchange of experience,
  - Polish scientist carring out CLC research in NETL DOE,
  - US partners visisting IChPW, common publications,
  - Samples exchange



Top 500 Innovators - Science, Management, Commercialization University of California, Berkeley, 2012

Ministerstwo Nauki i Szkolnictwa Wyższego

TOP 500 INNOVATORS SCIENCE MANAGEMENT COMMERCIALIZATION

The largest in the history of Polish Science training program for **researchers in the best academic centers in the world.**

Aim: development of qualifications of R&D, technology transfer, commercialization of the scientific results.

Internships: NASA, AutoDesk, PAX Water, Mozilla, HP, Synopsis, Internet2

Site visits: Crosslink Capital, oDesk, Intel Corporation, Plug and Play Tech Center, Stanford Linear Accelerator, Lawrence Livermore National Laboratory

Acknowledgements

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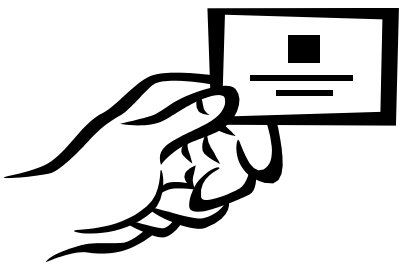
Narodowe Centrum Badań i Rozwoju

Questions?



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