GŁÓWNY INSTYTUT GÓRNICTWA

RESEARCH AND ACTIVITIES OF THE CLEAN COAL TECHNOLOGIES CENTRE

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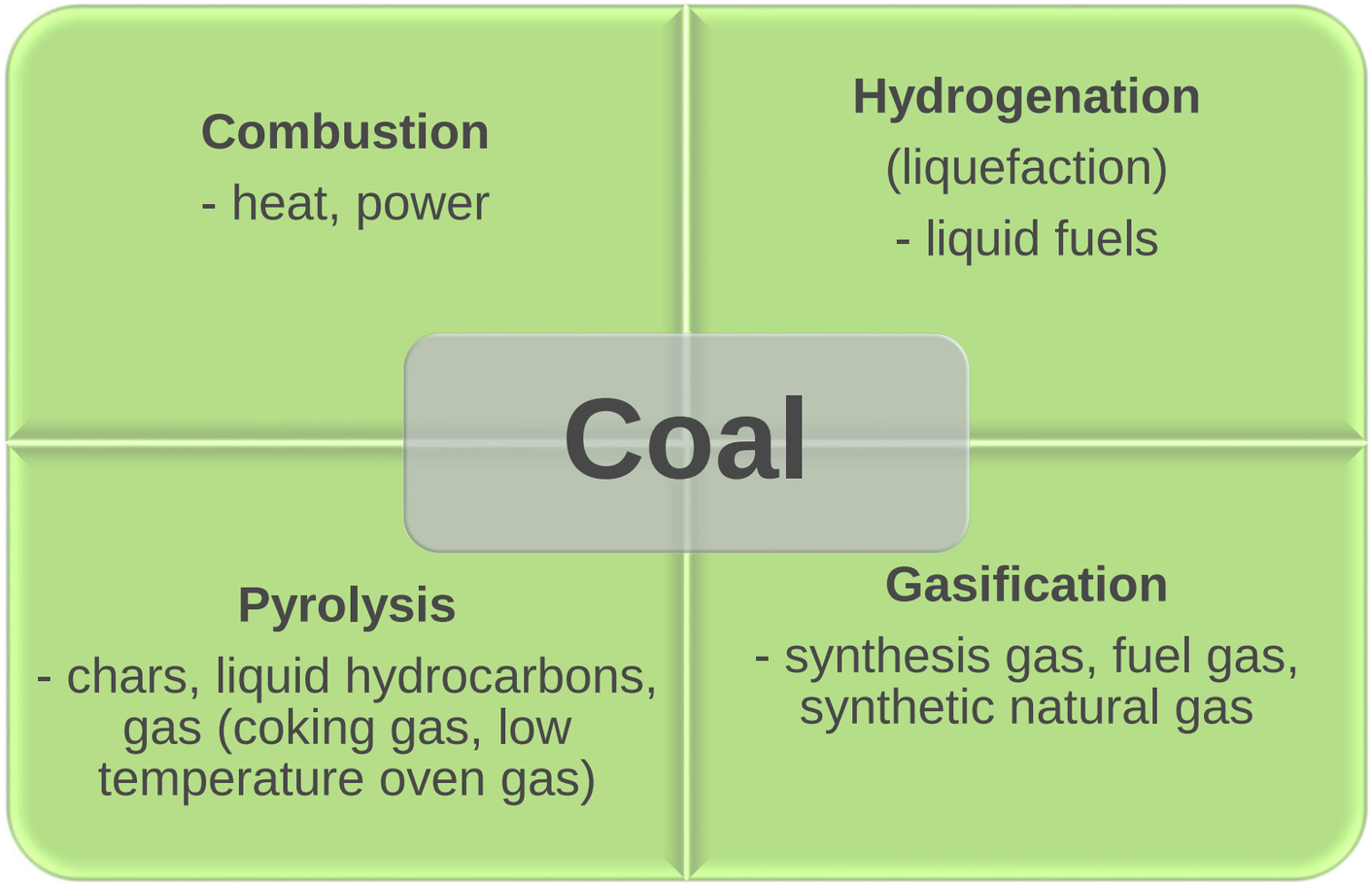
BASIC PROCESSES AND PRODUCTS OF COAL UTILIZATION



COAL GASIFICATION

Gasification of coal is the high-temperature thermochemical process of coal conversion into synthesis gas with the application of gasification agent, like e.g. steam, oxygen, air or carbon dioxide for highly efficient production of fuels and energy

Coal gasification technologies may be divided into:

- ❑ Surface
- ❑ Underground

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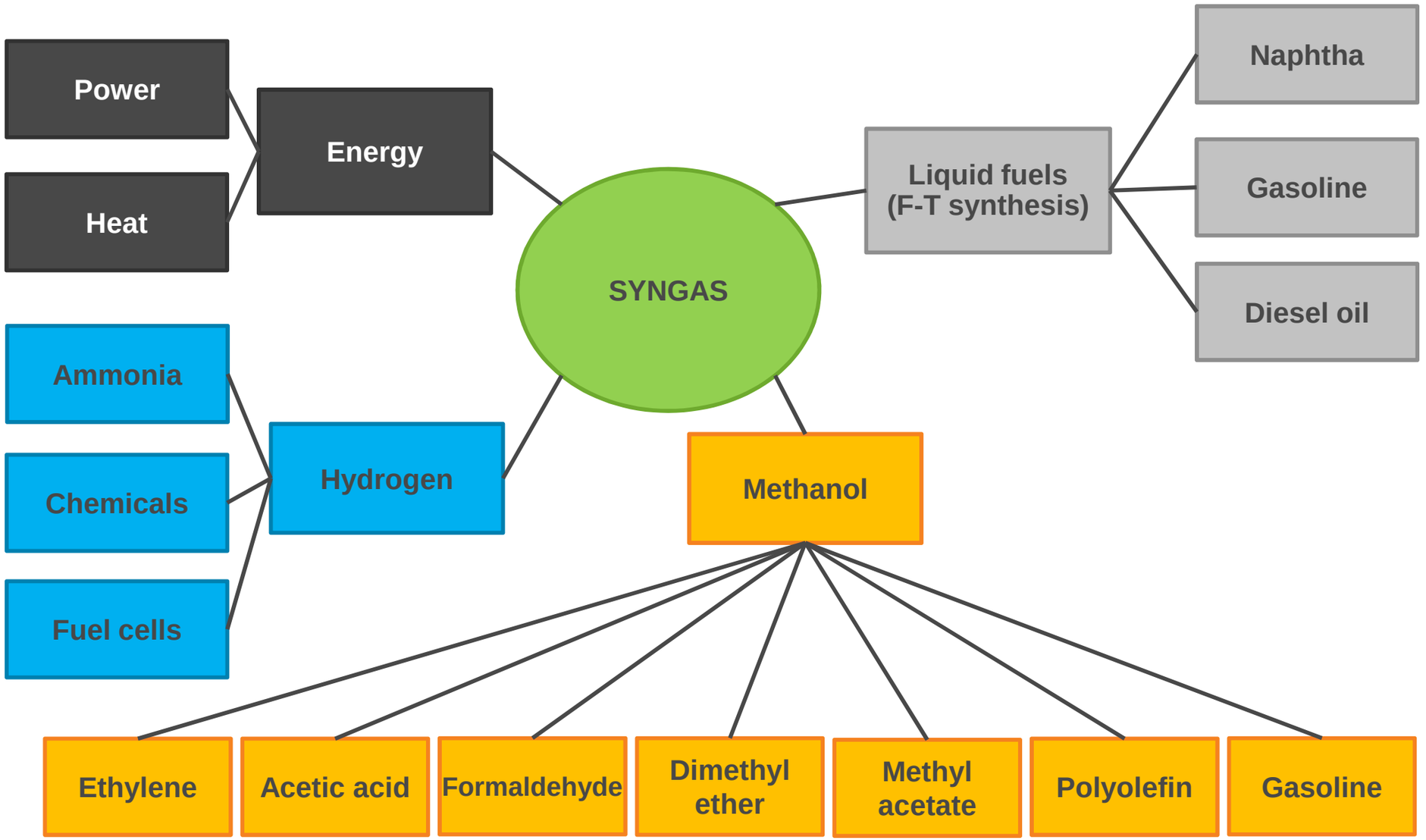
UTILIZATION OF COAL–DERIVED SYNTHESIS GAS



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CLEAN COAL TECHNOLOGIES CENTRE

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 scientifical 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.

CENTRAL MINING INSTITUTE

KATOWICE

MIKOŁÓW, KD BARBARA

INSTITUTE FOR CHEMICAL PROCESSING OF COAL

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CLEAN COAL TECHNOLOGIES CENTER

Katowice

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)
- CO_2 capture, storage and utilization (CCS and CCU)
- determination of physicochemical properties of coal and other solid fuels
- numerical modelling

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CLEAN COAL TECHNOLOGIES CENTER

MIKOŁÓW

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

Installation of gasification in a moving bed reactor

Installation for pressure simulation of underground coal gasification process

A non-pressure reactor for simulating the underground coal gasification process

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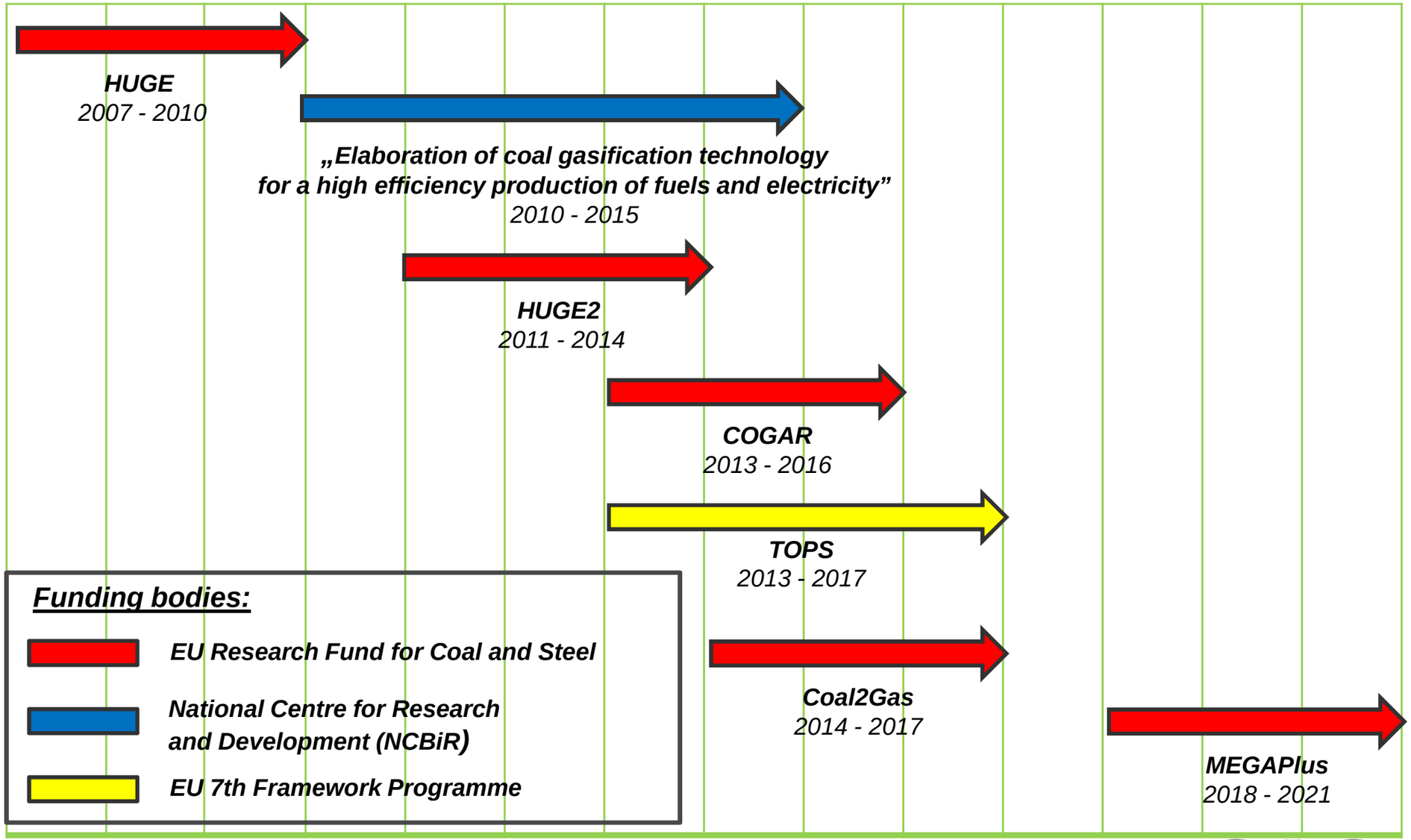
DEVELOPMENT OF UCG IN GIG: RESEARCH PROJECTS



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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.

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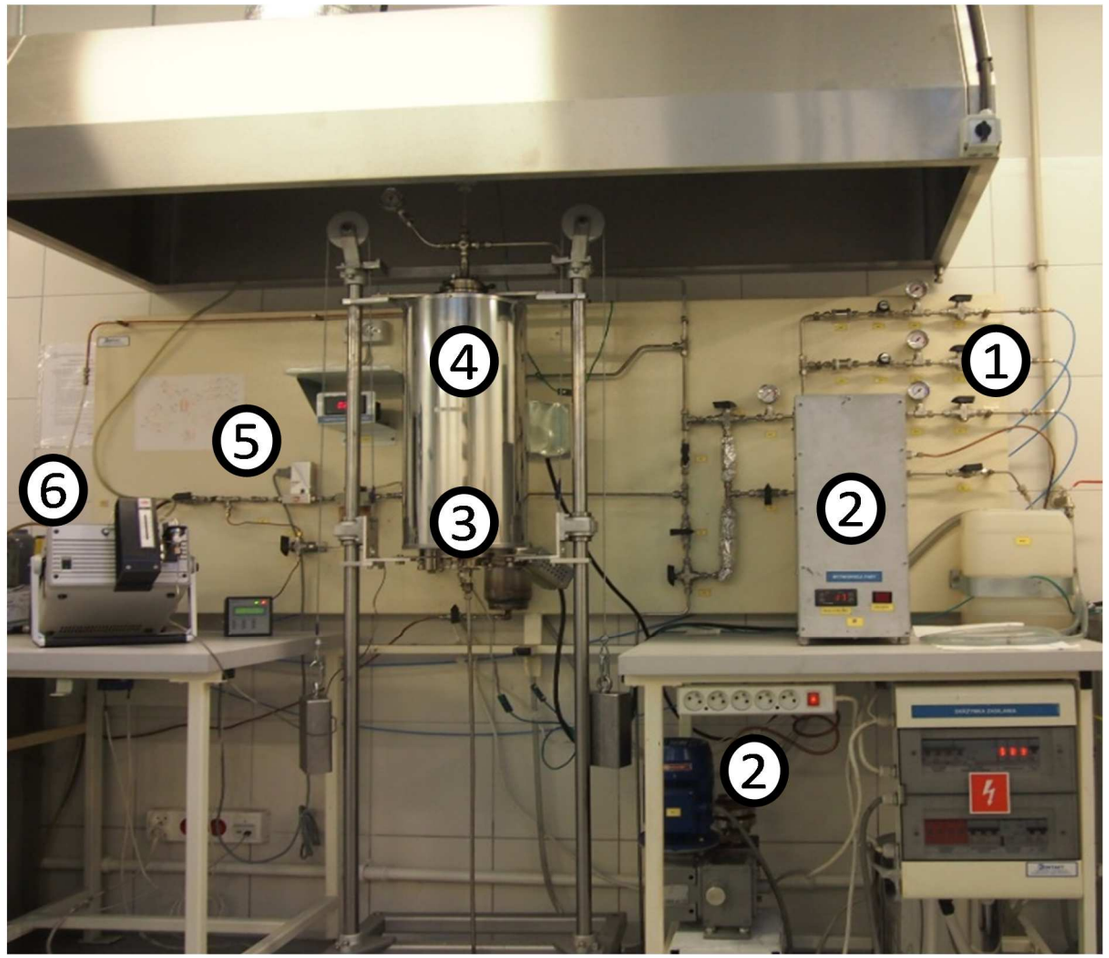
PGG COAL CHAR REACTIVITY AS A FUEL SELECTION CRITERION FOR GASIFICATION PROCESS



Fixed-bed reactor experimental stand with gasification agents pre-heating system

Thermogravimetric analyzer SDT Q600

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

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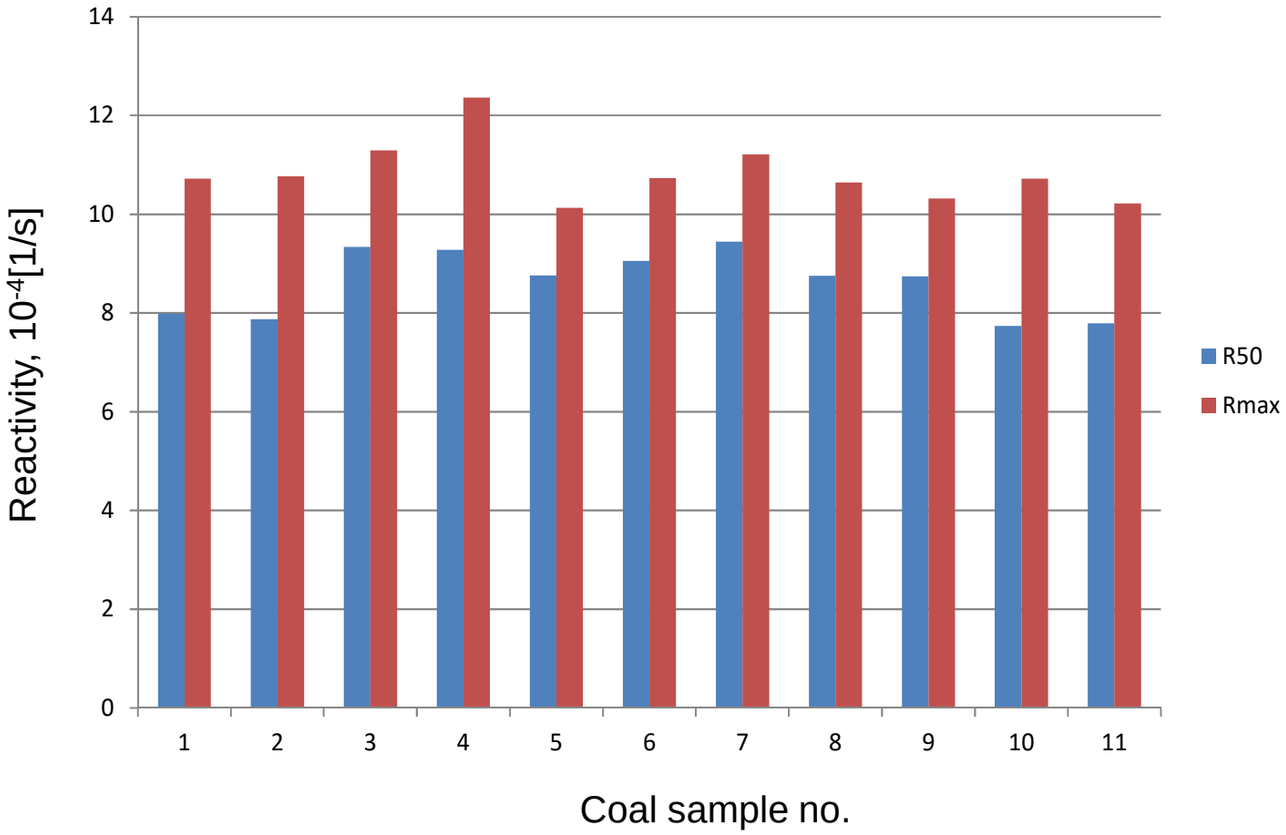
PGG COAL CHAR REACTIVITY AS A FUEL SELECTION CRITERION FOR GASIFICATION PROCESS



Coal chars reactivity for 50% of carbon conversion, R_{50}, and the maximum reactivity, R_{max}

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.

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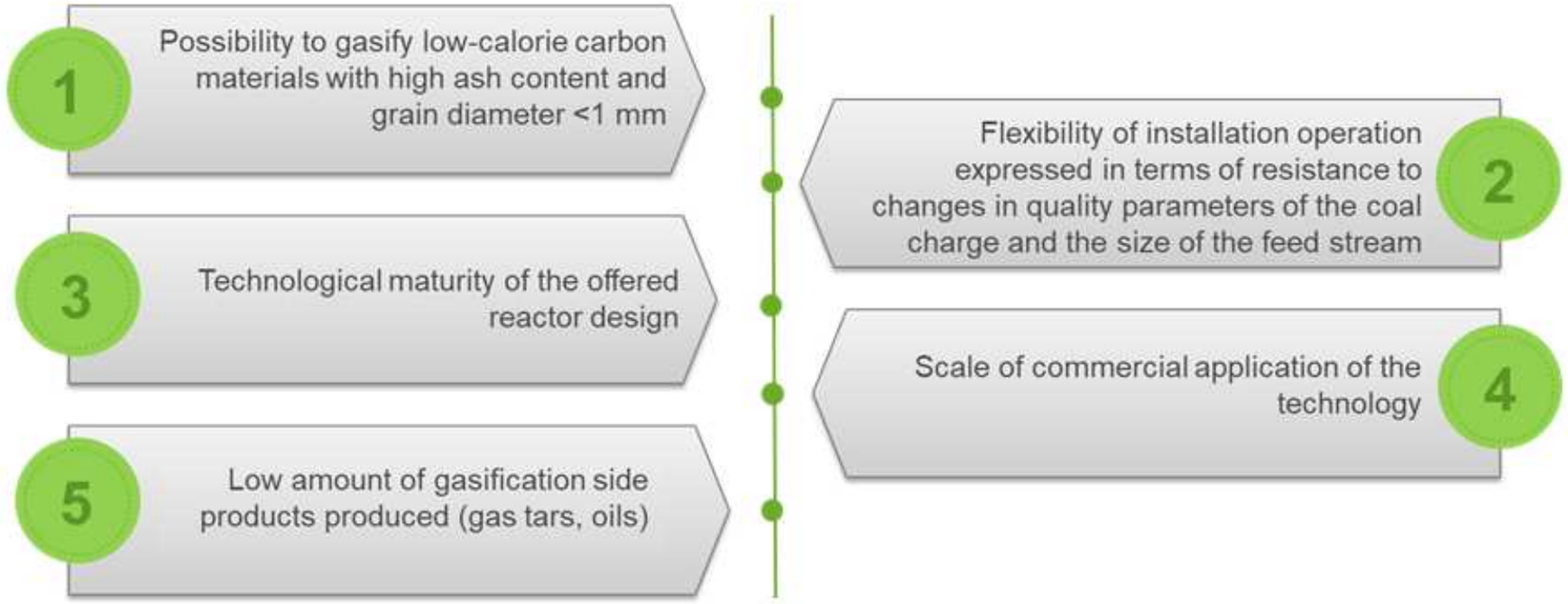
COMPARATIVE ANALYSIS OF SELECTED GASIFICATION TECHNOLOGIES FROM THE PERSPECTIVE OF POLISH MINING GROUP CONDITIONS

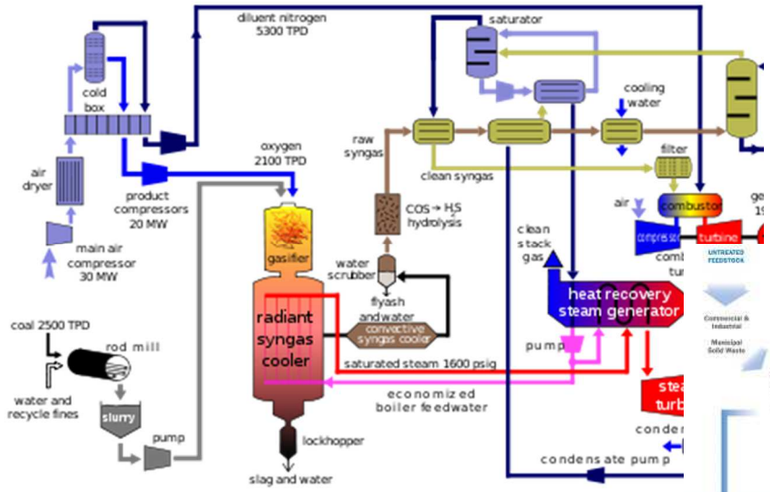
The main objective: to identify a technology that is technically, economically and environmentally optimal for implementation on the basis of quantitative and qualitative factors for electricity production.



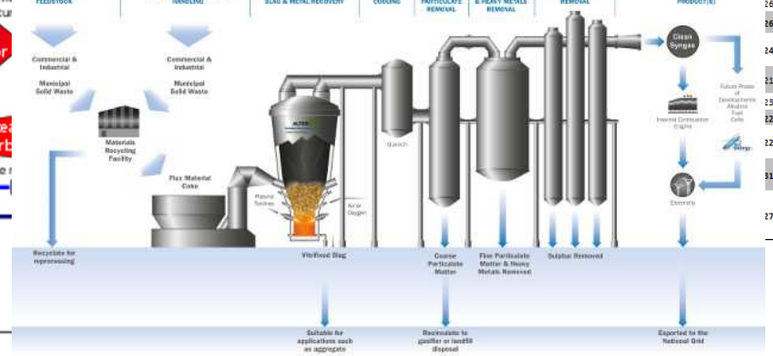
Number of criteria for the assessment of gasification technologies has been implemented

APPLIED METHODS OF ANALYSIS

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).



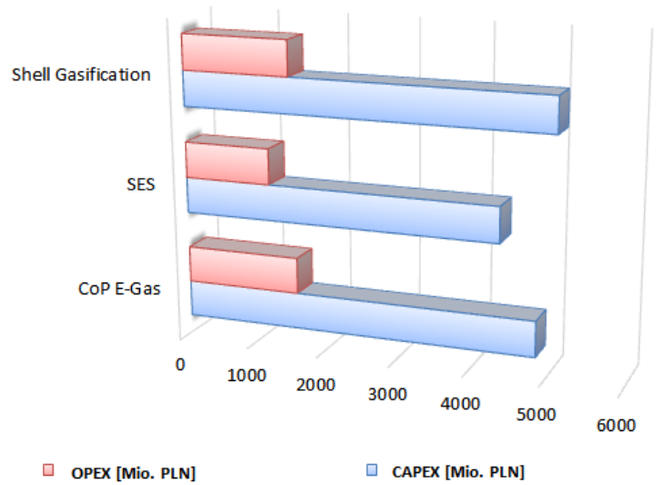
Division	District	Current production: Floation concentrat	Qir	Ar	Wtr	Str	Mut surowy	Qir	Ar	WtrP	Str	Production of waste from flotation: Amount	Qir	Ar	Wtr	Str	Crude silt as extractive waste
		ton	KJ/kg	%	%	%	ton	KJ/kg	%	%	%	ton	KJ/kg	%	%	%	Mg
SOŚNICA		60,012.0	19,450	15.0	22.8	0.74	1,800.0	14,900	32.0	18.3	0.85	32,896.0	4,980	57.0	22.0	0.70	
BOLESŁAW ŚMIAŁY		0.0					37,009.0	10,000	36.0	25.0	0.60	0.0					0.0
KWK RUDA	Halemba	0.0					4,920.0	14,959	22.6	29.1	0.51	0.0					0.0
	Pokój	0.0					0.0										
	Bielszowice	0.0					166,805.5	18,534	15.4	27.8	0.42						
	Razem	**0.0**					**171,725.5**	**18,432**	**15.6**	**27.8**	**0.42**						
KWK PIAST - ZIEMOWIT	Piast I	0.0					7,996.0	9,822	36.8	26.2	0.72						97,202.0
	Piast II	0.0					2,063.0	9,469	28.9	34.9	0.65						14,188.3
	Ziemowit	0.0					28,500.0	8,168	30.0	37.5	0.84						
	Razem	**0.0**					**38,559.0**	**8,581**	**31.4**	**35.0**	**0.80**	**0.0**					**111,390.3**
KWK ROW	Chwałowice	0.0					0.0					0.0					35,326.7
	Jankowice	56,860.0	19,000	18.0	35.0	0.60	0.0					192,355.0	-	51.8	-	-	0.0
	Marcel	144,260.0	22,000	7.0	31.0	0.60	0.0					38,326.0	4,347	55.8	20.6	1.17	0.0
										26.5	0.36	0.0					0.0
										26.5	0.36	230,681.0	4,347	52.5	20.6	1.17	35,326.7
										24.6	0.33						
										21.5	0.71	0.0					0.0
										23.3	-	0.0					0.0
										22.6	0.71	0.0					0.0
										22.4	0.54						
										31.2	0.34	0.0					0.0
										27.0	0.46	263,577.0	4,426	53.0	20.8	1.11	146,717.0



APPLIED METHODS OF ANALYSIS

2. **Economic** analyses - CAPEX, OPEX, DGC (Dynamic Generation Cost):
   - ✓ investment outlays,
   - ✓ operating costs,
   - ✓ dynamic unit cost.

Description	CoP E-Gas	SES	Shell Gasification
Capital expenditure CAPEX [PLN]	4 847 981 491	4 359 062 400	5 077 787 581
Operating costs OPEX [PLN]	1 582 856 768	1 202 421 372	1 502 589 097



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

Description	Unit	Gasification technology		
		ConocoPhillips E-Gas	SES	Shell
Total discounted costs	PLN	16 619 687 274	12 414 048 074	16 252 542 696
Discounted sum of the amount of electricity produced	MWh	31 531 690	32 834 652	29 863 898

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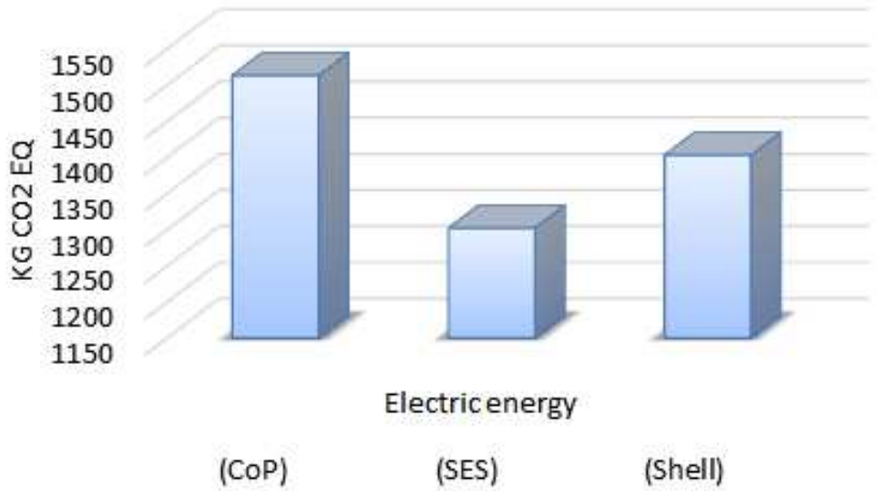
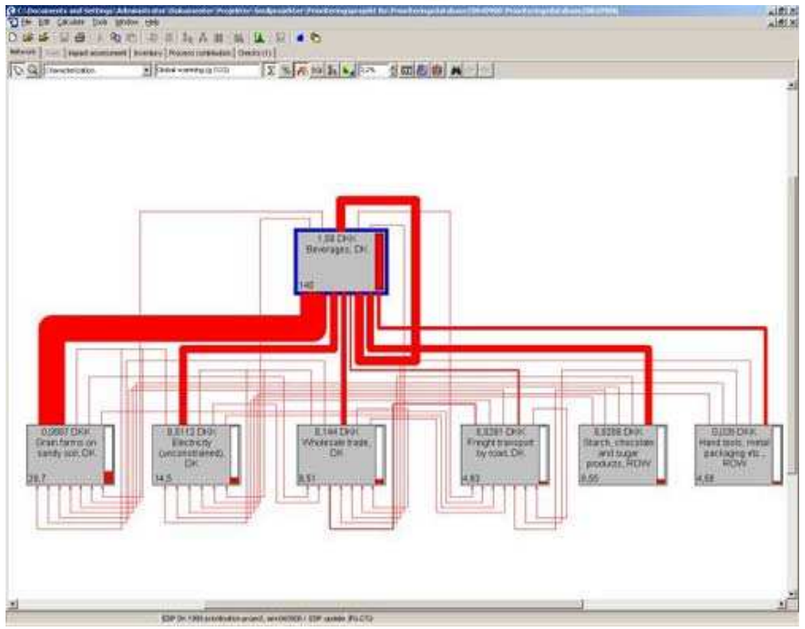
APPLIED METHODS OF ANALYSIS

3. **Environmental** analyses - LCA, carbon footprint:
   - ✓ assessment of the environmental impact of the gasification technology.
   - ✓ use of SimaPro software with Ecoinvent 3 database





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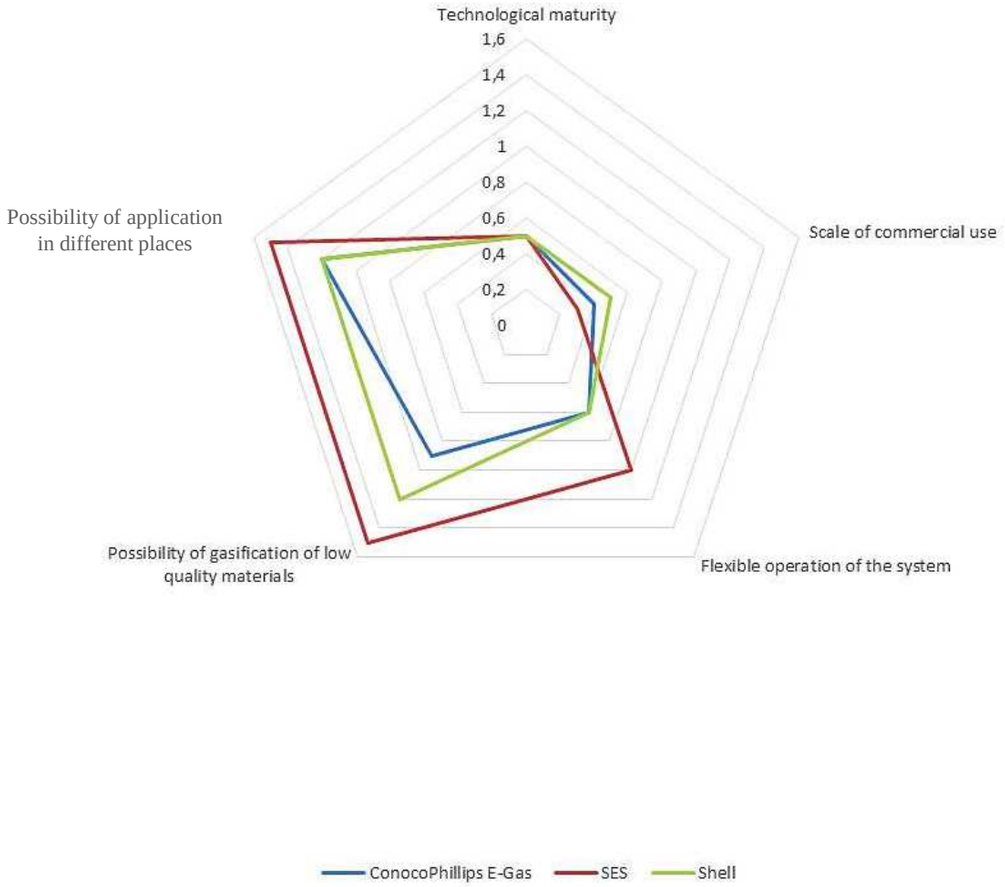
APPLIED METHODS OF ANALYSIS

4. Analyses **supporting** the decision making process – Multicriteria Analysis.



Wirl to Westfield	Options										
	Do Min	No Commuter Peak Freight	Freight priority in Commuter Peak	Freight by Road	Faster Freight Trains	Longer Freight Trains	Taller Freight Trains	Heavier Freight Trains	4th Main	3rd Main	Signalling Improvements
	0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Summary											
Objective 1 – Freight delays	0	--	+	-	+	+	+	+	+++	++	+
Objective 2 – PT Travel times	0	++	--	++	+	+	+	+	++	++	+
Objective 3 – Reduced freight on road	0	-	+	---	+	+	+	+	+++	++	-
Feasibility	0	0	-	0	-	-	--	--	--	-	--
Affordability	0	0	-	0	-	-	--	--	0	0	--
Public / Stakeholders	0	-	--	-	-	-	-	-	+	+	-
Cultural, Social and Environmental Effects	0	0	0	0	0	0	0	0	0	0	0
Safety	0	+	0	-	-	-	-	-	+++	++	+
Economy	0	0	-	0	+	+	+	+	+++	++	+
Ranking	3	8	11	10	4	4	7	6	1	2	9
Average score	**0.0**	**-1.6**	**-4.6**	**-4.6**	**-0.4**	**-0.4**	**-1.4**	**-1.3**	**12.5**	**10.1**	**-1.7**
Cost (Lower Bound)	0	$50	$20	$100	$50	$50	$350	$250	$150	$65	$100
Cost (Upper Bound)	0	$70	$30	$150	$70	$70	$450	$300	$200	$80	$200
Cost (Lower Bound) NPV	0	$45	$18	$89	$45	$45	$312	$223	$134	$58	$89
Cost (Upper Bound) NPV	0	$62	$27	$134	$62	$62	$401	$267	$178	$71	$178
Benefits NPV	0	$40	-$20	-$200	$30	$30	$50	$50	$150	$105	$50
BCR upper	0	**0.9**	**-1.1**	**-2.2**	**0.7**	**0.7**	**0.2**	**0.2**	**1.1**	**1.8**	**0.6**
BCR lower	0	**0.6**	**-0.7**	**-1.5**	**0.5**	**0.5**	**0.1**	**0.2**	**0.8**	**1.5**	**0.3**
Sensitivity Score		**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Objective 1 – Freight delays	3	9	10	11	4	4	7	6	1	2	8
Objective 2 – PT Travel times	3	10	8	11	4	4	7	6	1	2	9
Objective 3 – Reduced freight on road	3	4	11	8	6	6	10	9	1	2	5
Feasibility	7	9	10	11	3	3	6	5	1	2	8
Affordability	8	9	10	11	3	3	5	5	1	2	7
Public / Stakeholders	5	6	10	11	3	3	8	7	1	2	9
Cultural, Social and Environmental Effects	3	6	11	10	4	4	8	7	1	2	9
Safety	3	4	10	11	6	6	9	8	1	2	5
Economy	5	9	11	10	3	3	7	6	1	2	8

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

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