ENVIRONMENTAL IMPACT ASSESSMENT

and WASTE MANAGEMENT

Dr. Janina Fudala

Institute for Ecology of Industrial Areas, Katowice, Poland

Content of presentation

- Range of impact assessement
- Input data
- Results of SIA
- Results of LCA
- Results of EIA
- Conclusions

Range of impact assessement

- Safety Impact Assessment (SIA)
- Life Cycle Assessment (LCA)
- Environmental Impact Assessement (EIA)

Input data

Data for IGCC plant without CO2 capture and IGCC CLC plant
General plant parameters

Parameter	IG-CLC plant	IGCC plant without CO_2 capture	Data source
Net efficiency (%)	41,07	45,20	D 5.2
Net power (MWe)	350,68	367,3	D 5.2
Lifetime plant (years)	25	25	Preliminary economic analysis, FWI
Working hours/year	7621 (87% availability)	7621 (87% availability)	IGCC: Preliminary economic analysis, FWI, IG-CLC: assumed equal,
Land use, industrial area (km^2)	1,21	1,21	IGCC: from literature (NETL, 2010), IG-CLC: assumed equal,

Input data

Construction materials needed for IGCC-CLC/IGCC plant

Construction material	IG-CLC plant	IGCC płant without CO_2 capture	Data records (Ecoinvent)	Transport (estimates VITO)
Concrete (m^3/plant)	40 600	25 600	Concrete, normal, at plant/CH U	100 km by Transport, lorry >16t, fleet average/RER U
Carbon steel (tonnes/plant)	35 500	26 100	Steel, converter, unalloyed, at plant/RER U + Steel product manufacturing, average metal working/RER U	700 km by Transport, lorry >16t, fleet average/RER U
Light & high alloyed steel (tonnes/plant)	3 100	2 300	Chromium steel 18/8, at plant/RER U + Steel product manufacturing, average metal working/RER U	700 km by Transport, lorry >16t, fleet average/RER U
Copper (tonnes/plant)	360	240	Copper, at regional storage/RER U + Metal product manufacturing, average metal working/RER U	700 km by Transport, lorry >16t, fleet average/RER U
Aluminium (tonnes/plant)	80	50	Aluminium, production mix, at plant/RER U	700 km by Transport, lorry >16t, fleet

Inputs needed for the operation of IGCC-CLC / IGCC plants

Process inputs	IG-CLC plant	IGCC plant without CO2 capture	Data source	Data records (Ecoinvent)	Transport (own estimates)
Coal (kg/s)	34,13	30,5	D5.2	Hard coal mix, at regional storage/UCTE U	50 km by Transport, lorry >16t, fleet average/RER U
Selexol (kg/s)	0,00069	0,00074	EBTF/Polimi	Own approximation, per kg: 0,33 kWh Electricity, medium voltage, production RER, at grid/RER, 2 MJHeat, natural gas, at industrial furnace >100kW/RER U, 8E-10 p Chemical plant, organics/RER/I U, 0,23 kg Ethylene glycol, at plant/RER U, 0,82 kg Ethylene oxide, at plant/RER U	100 km by Transport, lorry >16t, fleet average/RER U
Oxygen carriers (kg/s)	0,012	/	estimate,	Based on info CTI, per kg: 0,75 kg Ilmenite, 54% titanium dioxide, at plant/AU U, 0,25 kg Mn3O4 (approximated by 0,26 kg Manganese oxide (Mn2O3), at plant/CN U, 0, 13 kWh Heat, natural gas, at industrial furnace low-NOx >100kW/RER U), 0,02 kg binder (approximation: Bentonite, at processing/DE U),	2000 km by Transport, lorry >16t, fleet average/RER U

Emissions to air produced during operation of IGCC-CLC / IGCC plants

Process outputs	IGCC-CLC plant	IGCC plant without CO_2 capture	Data source
CO_2 (kg/s)	3,25	78,2	D 5.2
SO_x as SO_2 (g/s)	negligible	2,69	Polimi
NO_x as NO_2 (g/s)	negligible	26,3	D5.1/Polimi
CO (g/s)	2,46	19,7	D5.1/Polimi
NMVOCs (g/s)	7,0	7,0	Elcogas data, assumed equal for IG-CLC,
PM10 (g/s)	0,94	0,94	Elcogas data combined with literature, assumed equal for IG-CLC,
PM2.5 (g/s)	0,46	0,46	Elcogas data combined with literature, assumed equal for IG-CLC,

Heavy metals emissions are at the same levels for IGCC – CLC and IGCC plant

Outputs (excl. Emissions to air) produced during operation of IGCC-CLC / IGCC plants

Process outputs	IGCC-CLC plant	IGCC plant without CO_2 capture	Data source	Data records (Ecoinvent)	Transport (own estimates)
Cooling water reinjected into river/lake (kg/s)	159,2	210,4	D5.1/Polimi	/	/
Process water reinjected into river/lake (kg/s)	2,31	8,5	D5.1/Polimi	Approximation waste water treatment: Treatment, sewage, to wastewater treatment, class 3/CH U	/
Ash waste (kg/s)	4,80	4,57	Polimi	Assumption European average utilisation and disposal coal combustion products (Feuerborn, 2011): 10% Disposal, hard coal ash, 0% water, to residual material landfill/DE U, 90% used in building industry (outside system boundaries)	100 km by Transport, lorry >16t, fleet average/RER U
Catalyst waste (kg/s)			to be included		
Oxygen carrier waste (kg/s)	0,014	/	estimate, to be updated	Approximation: Disposal, inert waste, 5% water, to inert material landfill/CH U	100 km by Transport, lorry >16t, fleet average/RER U
Sulphur, by-product (g/s)	175	166	Polimi	As sulphur is produced, less sulphur has to be made by other methods, so “Secondary sulphur, at refinery/RER U" is avoided.	/
Compressed CO_2 stream (kg/s)	82,27	/	Calculated from D5.2	Assumptions: - transport of CO_2: leakage negligible,	325 km in steel pipelines (Henkel , 2006), Ecoinvent

SAI – methodology

The safety impact model used for this study aims to accomplish the following three basic purposes:

- Safety information survey
- Classification of safety impact factors caused by CO_2 capture technologies
- Qualitative assessment of the safety impact factors

Two following methodologies were applied simulating a system without CLC technology and a system with CLC technology, in order to determine the safety impact of the CLC reactor in the IGCC facility:

- Methodology for the Identification of Major Accident Hazards - MIMAH (from EC FP5 project ARAMIS)
- Dynamic Procedure for Atypical Scenarios Identification DyPASI

SAI – results

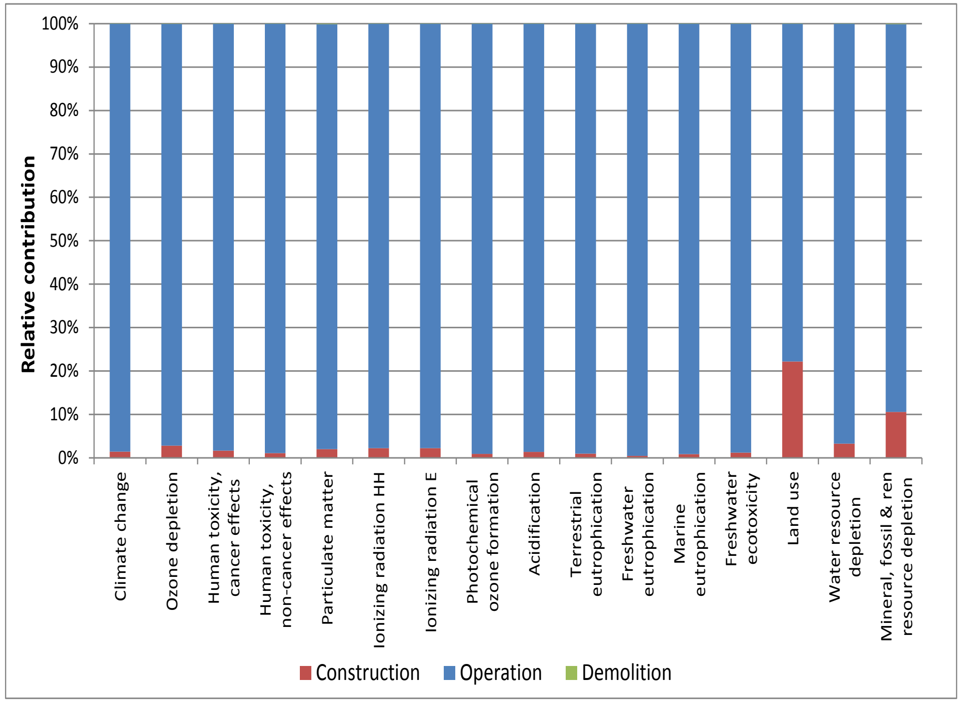
- The adoption of the CLC technology would sensibly change an IGCC plant. Not only the water gas shift step would be unnecessary, but also the CO_2 pre-combustion capture system, which uses flammable and toxic solvents such as Selexol and Rectisol would be removed
- Thus, a series of consequences, such as Pool fire, VCE, Flash Fire, Toxic Cloud, Jet-fire, etc. would become relatively less likely
- On the other hand, the CLC technology does not introduce any novelty in terms of safety for an IGCC plant with CO_2 capture

LCA – methodology

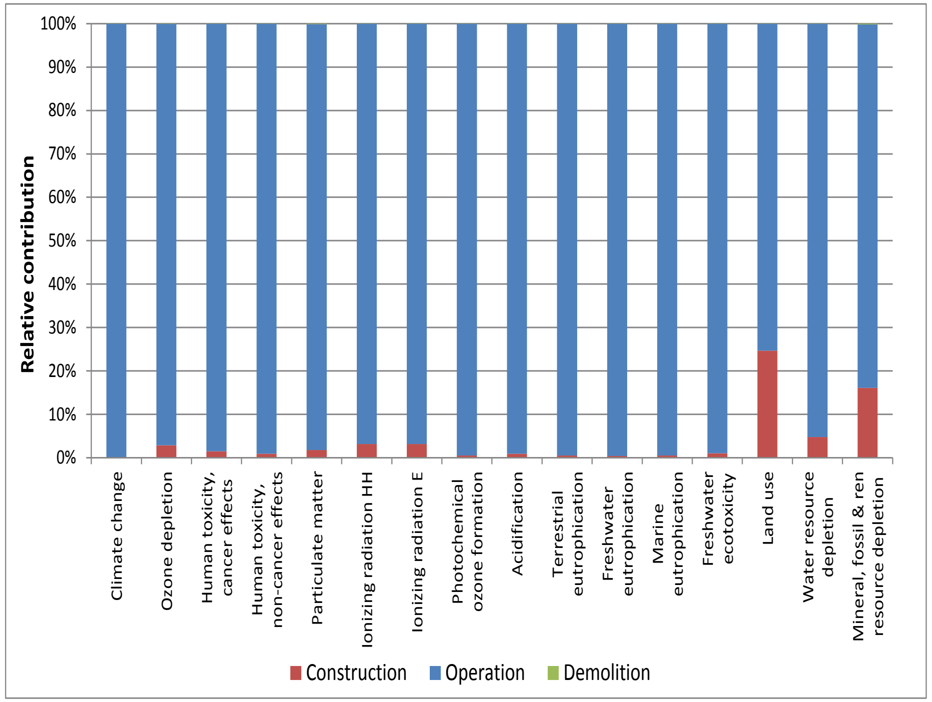
- Various methods are in use to assess the environmental impacts of products and systems. Almost all methods operate on the assumption that a product's entire life cycle should be analysed
- For this project VITO uses the different environmental impact categories defined by the ILCD (International Life Cycle Database) method
- The ILCD method is interesting to apply because it is a mix of most recommended methods per environmental impact category as recommended by the European Commission. VITO refers to paragraph 2.3.6 for the summary table with all environmental impact categories
- VITO uses the LCA software package "SimaPro 8.0.2" for performing the life cycle impact assessment (LCIA) and generating the environmental proiles

LCA – results

IGCC – CLC environmental profiles



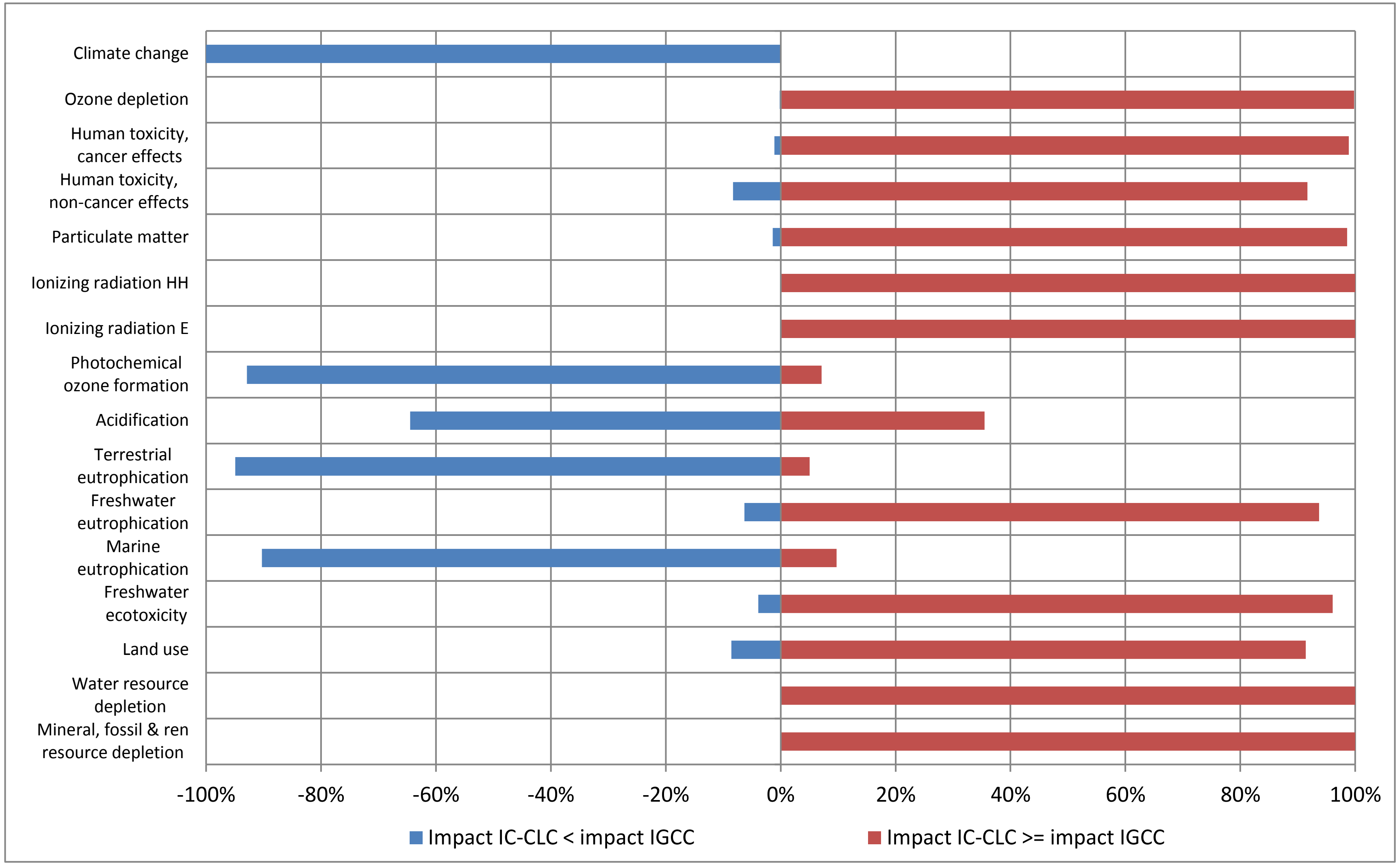
IGCC without CO2 capture environmental profiles



For IGCC – CLC less impact for land use, water resources depletion and mineral fossil resouces depletion

LCA

Monte Carlo simulation of the comparison of one kWh of electricity produced in the IGCC-CLC plant IGCC plant



LCA – conclusions

- The environmental impact of electricity production is mainly determined by the operation of the plants, while the construction accounts for less than 1/4th of the total impact and the impact of the demolition at the end of life is negligible
- The environmental impact of the operation of the plants is mostly determined by the production and transport of coal, direct process emissions and the transport and storage of CO_2 (for the IGCC-CLC plant)
- Furthermore, electricity production in an IGCC-CLC plant resulted better for climate change and 3 other impact categories than electricity production in an IGCC plant, but worse for many others

EIA – analysed components

- Impact on the air quality
- Impact on water consumption and quality of discharged waters to surface waters
- Waste management
- Impact on noise

Air emissions standards for power plants

European Union Industrial Emissions Directive 2010/75/EU appendix 5

	Pollutant	Emission Limit	Notes
Coal PC Boilers	SO_2	< 150 mg/Nm^3	6%vol. O_2 , dry
	NO_x	< 150 mg/Nm^3	
	Particulate	< 10 mg/Nm^3	
TG (IGCC)	NO_x	< 50 mg/Nm^3	15%vol. O_2 , dry
	CO	< 100 mg/Nm^3	
	Particulate	< 5 mg/Nm^3	
	SO_x	minimum desulphurization efficiency: 97%	

Emission points to air of IGCC and IGCC CLC technology

- Preparation of fuel (coal, biomass) for gasification (PM10)
- Syngas cleaning process (SO2)
- CCS installation (VOCs emission from Selexol) – only IGCC CCS plant)
- Gas Turbine exhaust gases (in the case of IGCC CLC emissions are close to zero)
- CLC reactor – possible PM10 emission

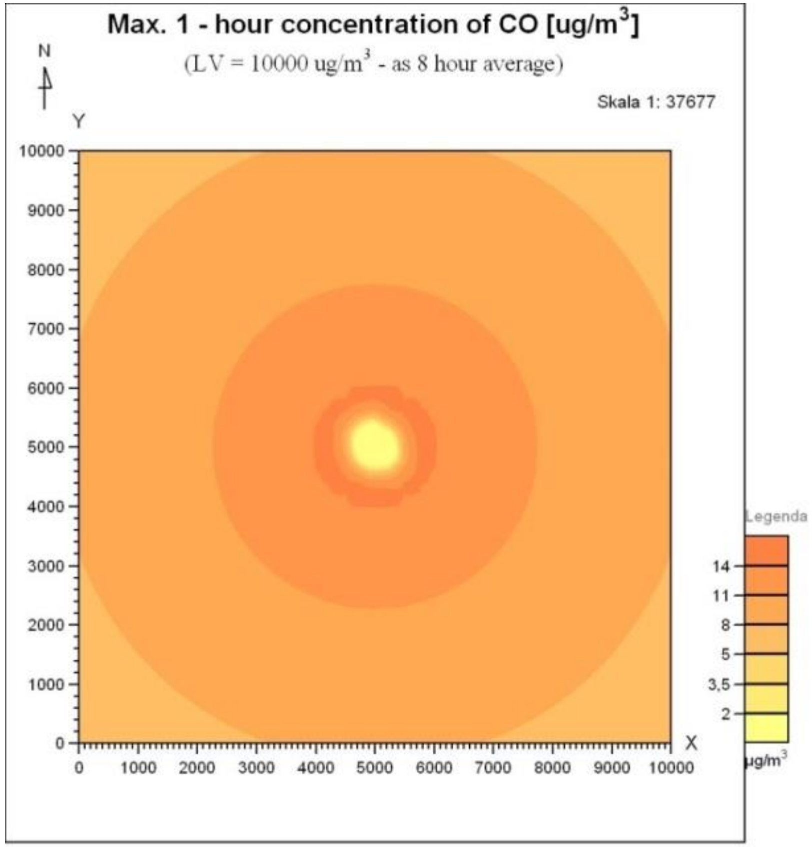
Air emissions of IGCC CLC technology

- Specific emissions to air for IGCC CLC plant and reference technologies are presented in D5.4 report – only CO_2, NO_x, SO_2 and PM10 are included (lack of data for CO and heavy metals)
- Lower air emissions from IGCC-CLC in comparison to reference plant (only PM10 emissions have been occurred, gaseous pollutants are captured together with CO_2)

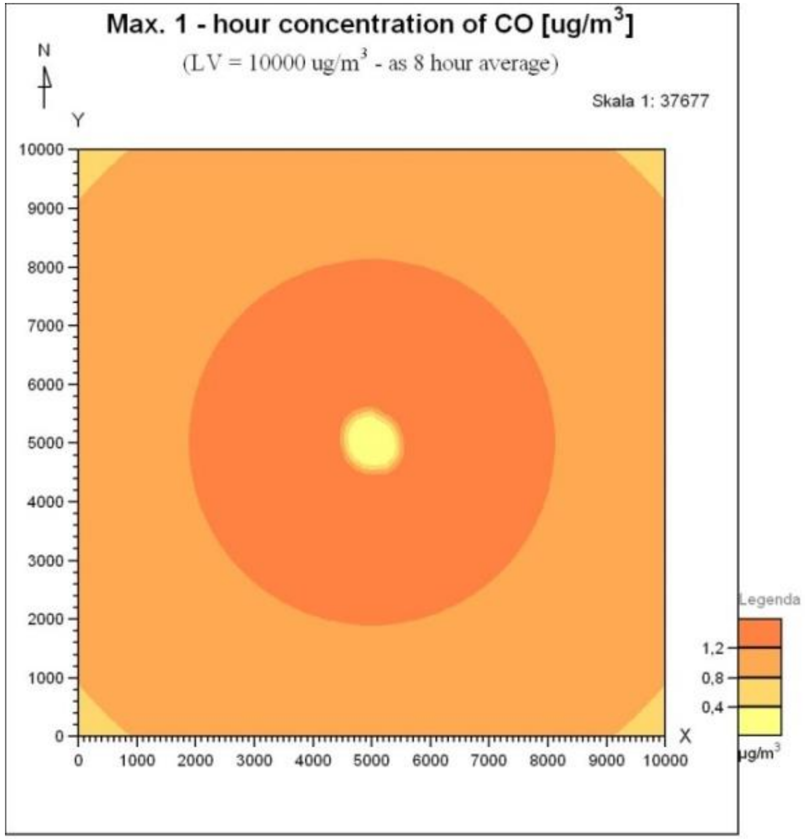
EIA – impact on the ambient air pollutant concentrations

- Lower calculated concentration of pollutants in ambient air (max. hourly PM10 concentration up to 2 μg/m³ – existing standard 50 μg/m³)
- Lower calculated concentrations of gaseous pollutants

IGCC plant



IGCC CLC plant



EIA – impact on water consumption

Water input and output for IGCC and IGCC-CLC power plants (l/s)

Process inputs	IGCC-CLC plant	IGCC plant without CO_2 capture
Inputs:		
Cooling water	318.50	420.80
Process water	19.40	14.50
Outputs:		
Cooling water reinjected into river/lake	159.20	210.40
Process water reinjected into river/lake	2.31	8.50

IGCC-CLC plant - water input for individual processes (l/s)

Process	Water input [l/s]
Saturator	4.8
Syngas scrubber	9.41
Steam to gasifier	2.87
Steam cycle make-up	2.31
Cooling water make-up	318.5
Total	***337.89***
Total [m^3/a]*	***9 270 215***

IGCC-CLC plant - water ouput for individual processes (l/s)

Process	Water output [l/s]
Water evaporated (cooling tower)	159.2
Water blow down (cooling tower)	159.2
Condensed process water from syngas cooling	10.58
Condensed process water from CO2 cooling	18.08
Steam cycle drum blow-down	2.31
Total	***349.37***
Total [m3/a]*	***9 585 176***

EIA – amounts of contaminants in sewage carried to the receiver

Amount of wastewater requiring treatment will decrease from 8.5 l/s to 2.31 l/s

Parameter	IGCC	IGCC - CLC
	kg/a	kg/a
TSS	66 676	18 120
COD	69 253	18 821
N-NH3(N)	58 781	15 975
Zn	297	81
As	22	6
Ni	250	68
Pb	55	15
Hg	11	3
Cd	11	3
Cu	15	4
Total cyanides	228	62
F	4 363	1 186
S_{2-}	132	36
SO_3	5 496	1 494
SO_4	395 731	107 546

EIA – waste management

Hazardous waste characteristics and production rates

Description of waste	EWC code**	Maximum ratio [kg / MWh]
Waste from gas cleaning containing dangerous substances - sulfur out of specification	10 01 18*	0.024198
Absorbents contaminated with dangerous substances	15 02 02*	0.010501
Mineral-based non-chlorinated engine, gear and lubricating oils	13 02 05*	0.019215
Oily water from oil/water separators	13 05 07*	0.019148
Hydrochloric acid *(Agua de lavado químico)*	06 01 02*	0.003870
Waste from gas cleaning containing dangerous substances – Rashig rings	10 01 18*	0.001109
Lead batteries / Mercury-containing batteries	16 06 01* / 16 06 03*	0.000555
Other solvents and solvent mixtures	14 06 03*	0.000444
Packaging containing residues of or contaminated with dangerous substances *(industriales)*	15 01 10*	0.002350
Packaging containing residues of or contaminated with dangerous substances *(laboratorio)*	15 01 10*	0.000250
Sludge containing dangerous substances from other treatment of industrial wastewater	19 08 13*	0.035813
Waste from gas cleaning containing dangerous substances - filter bags	10 01 18*	0.008520
Waste from gas cleaning containing dangerous substances - MDEA methyldiethanolamine	10 01 18*	0.302866
Cytotoxic and cytostatic medicines	18 01 08*	0.000140
Inorganic waste containing dangerous substances	16 03 03*	0.006135
Discarded electrical and electronic equipment not mentioned in 20 01 21 and 20 01 23 containing hazardous components	20 01 35*	0.000115
Waste whose collection and disposal is subject to special requirements in order to prevent infection	18 01 03*	0.000032
Waste from gas cleaning containing dangerous substances - cleaning plant residue	10 01 18*	0.137965
Saturated or spent ion exchange resins	19 08 06*	0.052142
Fluorescent tubes and other mercury-containing waste	20 01 21*	0.001187
Waste from gas cleaning containing dangerous substances - ceramic candles	10 01 18*	0.024687
Chlorofluorocarbons, HCFC, HFC	14 06 01*	0.000345

EIA – waste management conclusions

- Wastes generated during the operation of both installations will not create any significant risk for the environment as long as the commonly used procedures and provisions related to waste management are respected
- Waste must be collected separately in a manner that prevents contamination of the soil, surface and groundwater, under conditions which prevent dusting of loose waste and access to bystanders
- Hazardous waste must be collected separately in labeled containers suitable for properties of the waste and only for the time necessary to prepare the party for reception by a licensed recycler or firm responsible for their disposal

Conclusions

- High electric efficiency of HGCC – CLC technology – 40,8 % (IGCC-CCS – 35,3%, IGCC without capture – 45,2%)
- High CO_2 capture efficiency (96.1%) and low CO_2 specific emission (33,5 g/kwh - about 33% of the correspondent parameter for the IGCC with carbon capture with selexol)
- Exhaust gas stream not diluted with nitrogen
- Raw water consumption about 700 m^3/h - lower then for reference s.C. Technologies (about 1000 m3/h)
- Liquid effluents stream of IGCC – CLC technology (215 m^3/h) comparable to reference technologies (193-264 m^3/h)
- Due to quality standards for air and water established to protect of human health the both compared technologies cannot adversely affect the people

Thank you for your attention

jfudala@ietu.katowice.pl