Coal hydro-gasification and renewable energies for SNG production

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Introduction

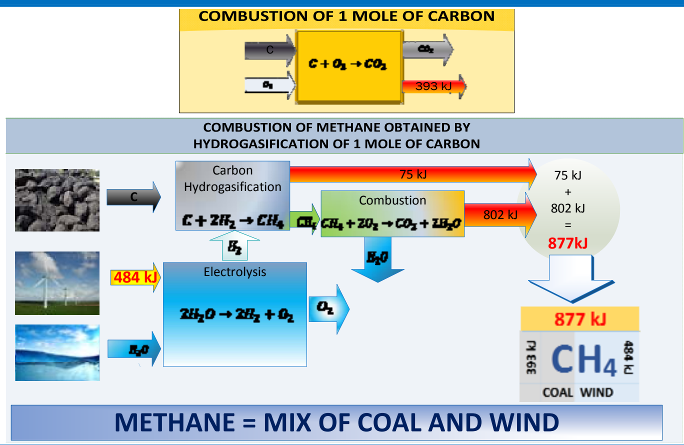
Coal in future energy scenarios
Energy demand is increasing across the globe and several countries have abundant coal resources. However, the large use of fossil fuels produced the increase of the concentration of greenhouse gases in the atmosphere that is considered to be responsible for the climate changes.

SNG a mix of fossils and renewables
Substitute Natural Gas (SNG) is produced via hydrogasification of coal by using low-cost hydrogen obtained by renewable energies (Coal2gas). The SNG obtained in this way is a mix of fossil (coal) and renewable energy (wind or solar) and thus increases the social acceptability of the coal exploitation.

Coal2gas as an option for storage of renewable energy
Presently, in many Countries further penetration of renewable energies needs the development of efficient storage systems. Renewable energies, particularly wind and solar, can be stored in chemical form (SNG) during off-peak hours by producing low-cost hydrogen needed for coal hydrogasification. In this way, SNG is an energy vector that can be transported and distributed using efficient and well-proven technologies.

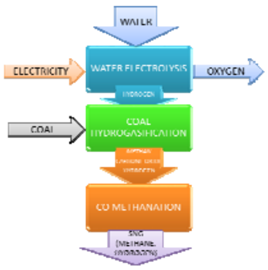
Coal2gas vs energy security
SNG could be a major driver for energy security. SNG production could diversify energy options and reduce natural gas imports, thus developing the flexibility and competitiveness of the energy market.

Enthalpy Balances

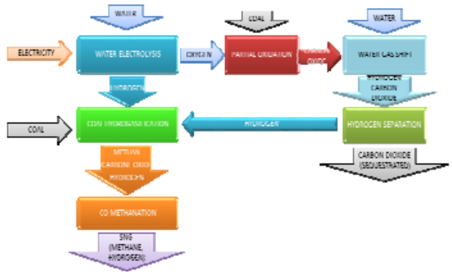


Wind + Coal = Substitute Natural Gas (SNG)

Two process options (basic process and its combination with WGS) have been analyzed through a simulation software (aspenONE® v8.4) [1, 2]: the model has taken into consideration a series of adiabatic reactors interspersed with heat exchangers for temperature control. Temperatures into the hydrogasification reactor ranges from 800 °C to 1000 °C. CO methanation has been realized in three reactors with intermediate cooling. The inlet temperature of the methanation reactors is 300 °C while their outlet temperature increases significantly because of the exothermicity of the reaction, while the WGS occurs in one high temperature reactor at 400 °C.



BASIC PROCESS



COMBINATION WITH WGS

COMPOSITION wt.% OF COAL	IT	DE1	DE2	UK1	UK2
C	53.17	73.78	56.60	77.45	68.00
H	3.89	4.58	3.50	4.50	3.00
S	5.98	0.75	0.70	1.50	0.30
N	1.29	1.63	1.40	2.00	1.25
O	6.75	4.58	6.00	4.50	7.40
Cl	0.10	0.14	0.10	0.35	0.05
ASHES	17.31	7.94	25.00	5.00	10.80
MOISTURE	11.51	6.60	7.50	3.75	9.20

The results of the process simulation are applied to the hydrogasification of coals coming from different European regions.
Geographical areas characterized by presence of both coalfields and high wind speed have been selected for the application of coal hydrogasification processes:
- Italy (Sulcis) IT, low quality coal with high sulfur content
- Germany DE1 with high carbon content
- Germany DE2 with low carbon and high moisture content
- United Kingdom UK1 from Kellingley, coal with high carbon content
- United Kingdom UK2 from Longannet (largest superficial UK mine)

[1] S. Tosti, A. Pizzuto, Processo per la produzione di metano da carbone, Italian Patent RM2012A000665 (2012)
[2] G. Buceti, D. Capobianco, G. Spazzafumo, S. Tosti, Wind & coal to generate a Substitute of Natural Gas by hydro-gasification in Europe, submitted to International Journal of Hydrogen Energy

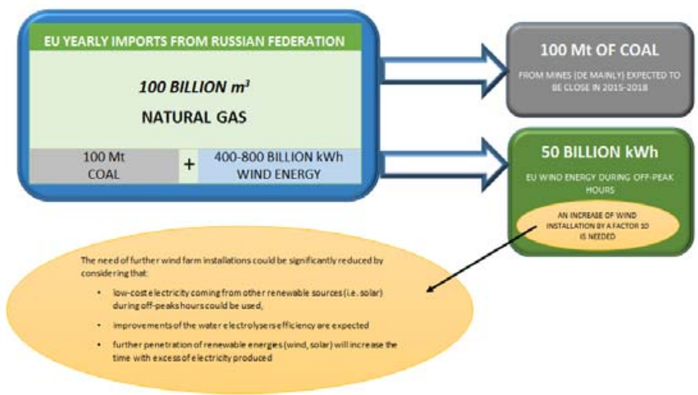
Perspectives for EU energy policy

The model analysis has been applied to the basic process and to the basic process in combination with the water gas shift.
The water electrolysis consumption are reported for the cases of:
a) CWE electrolysers having low efficiency but using a mature technology
b) high efficient HTE electrolysers (still to come at level of large-scale applications)

Basic process followed by CO methanation – Treatment of 1 Mt of coal	CH_4 PRODUCED [Nm^3]	H_2 CONTENT IN SNG [vol. %]	WATER ELECTROLYSIS ENERGY CONSUMPTION (CWE-HTE)	OXYGEN FROM ELECTROLYSIS [Nm^3]
IT	0.98×10^9	2.89	$8.14 \times 10^9 – 5.98 \times 10^9$	0.83×10^9
DE1	1.28×10^9	-	$9.79 \times 10^9 – 7.20 \times 10^9$	1.00×10^9
DE2	1.05×10^9	8.07	$9.25 \times 10^9 – 6.80 \times 10^9$	0.94×10^9
UK1	1.44×10^9	0.86	$1.20 \times 10^{10} – 8.82 \times 10^9$	1.22×10^9
UK2	1.27×10^9	9.67	$1.20 \times 10^{10} – 8.82 \times 10^9$	1.22×10^9

Combination of basic process with WGS - Treatment of 1 Mt of coal	CH_4 PRODUCED [Nm^3]	H_2 CONTENT IN SNG [vol. %]	WATER ELECTROLYSIS ENERGY CONSUMPTION (CWE-HTE) [kWh]	PSA ENERGY CONSUMPTION [kWh]
IT	5.65×10^8	1.99	$2.05 \times 10^9 – 1.51 \times 10^9$	5.49×10^8
DE1	7.92×10^8	2.40	$3.09 \times 10^9 – 2.27 \times 10^9$	7.62×10^8
DE2	5.97×10^8	1.15	$2.06 \times 10^9 – 1.51 \times 10^9$	5.71×10^8
UK1	8.28×10^8	0.66	$3.44 \times 10^9 – 2.52 \times 10^9$	8.18×10^8
UK2	7.08×10^8	0.85	$3.09 \times 10^9 – 2.27 \times 10^9$	7.21×10^8

The consumption of natural gas represents approximately 25% of the EU28 gross energy consumption while the imports of natural gas accounts for about 422×10^9 Nm^3 (106×10^9 Nm^3 from Russian Federation).



Conclusions

The hydrogasification of coal with hydrogen produced via wind electricity meets most of the core principles of the path to energy security as recently established by the G7 [3]:
- develops the flexibility and competitiveness of the energy market,
- permits the diversification of the fuels,
- promotes the deployment of clean and sustainable energy technologies,
- may improve the capacity of facing emergency situations, by increasing the fuel reserves and allowing the fuel substitution for the European Union that could suffer in the next future of shortage of natural gas.

[3] G7 ROME ENERGY MINISTERIAL MEETING - ROME G7 ENERGY INITIATIVE FOR ENERGY SECURITY - JOINT STATEMENT, Rome, May 6th 2014

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