BIONICO PROJECT - PRELIMINARY ASSESSMENT OF HYDROGEN PRODUCTION FROM BIOGAS USING A FLUIDISED BED CATALYTIC MEMBRANE REACTOR

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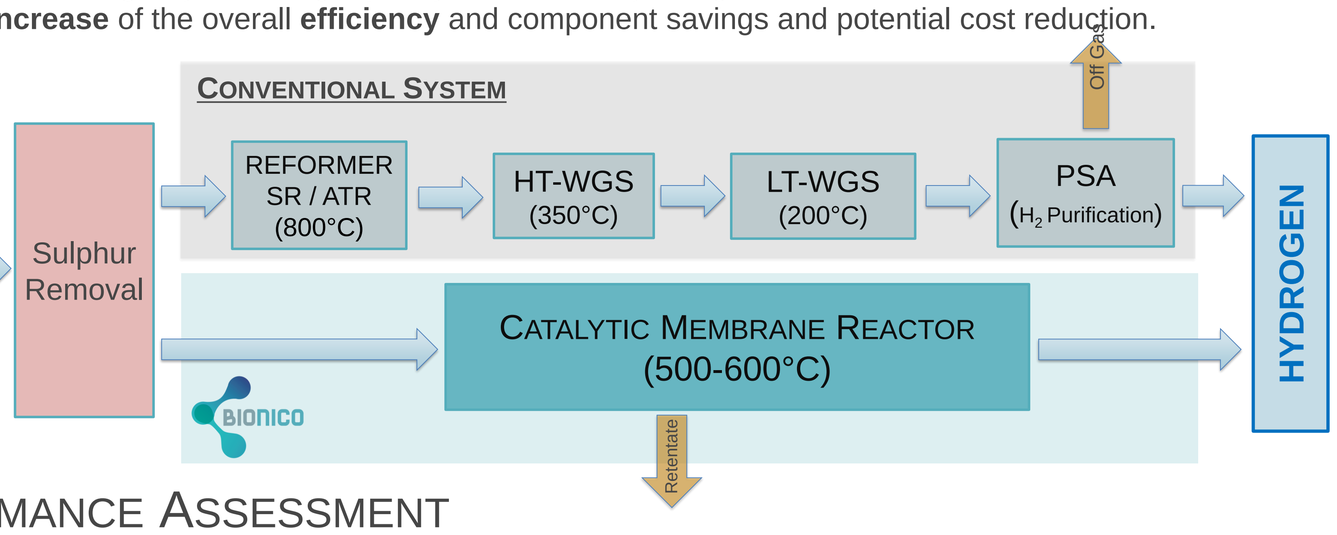
MOTIVATION AND CONCEPT

The current challenges of energy saving and reduction of CO_2 emissions must deal with the significant growth of energy demand. Hydrogen is a promising energy carrier that can replace fossil fuels in power generation and transportation, drastically reducing local pollution and CO_2 emission. In order to have a sustainable hydrogen economy, conventional production processes based on natural gas steam reforming have to be replaced with alternative production systems relying on renewable energy sources. The BIONICO project uses biogas, obtained by anaerobic digestion of residual biomass or other waste material, as a renewable source for **green hydrogen production**.

The BIONICO project will develop, build and demonstrate a novel reactor concept integrating H_2 production and separation in a single vessel in a biogas production plant. The hydrogen production capacity will be of **100 kg/day**, with target **purity** of **99,99%**. By using the novel intensified reactor, direct conversion of biogas to pure hydrogen is achieved in a single step, which results in an **increase** of the overall **efficiency** and component savings and potential cost reduction.



8 Partners (3 RES, 3 IND, 2 SME)
7 Countries (IT, ES, NL, DE, UK, PT, CH)
3.4 M€ project (3.1 M€ funded)
42 months
✓ Sept. 2015 Project STARTS
✓ June 2018 Reactor prototype ready
✓ Sept. 2018 Pilot plant start-up

PRELIMINARY PERFORMANCE ASSESSMENT

Three different fuel processors and their relative balance of plant are modelled in **Aspen Plus**®, where mass and energy balances are solved; all the modelled reactors (SMR, ATR, ATR-MR, HT-WGS, LT-WGS), considering the relatively high catalyst load, were assumed to achieve chemical equilibrium determined through Gibbs free energy minimization. The analysis consider that biogas flow is already exempt of sulphur content adopting a sulphur removal unit (e.g. based on active carbon) upstream the reforming system to avoid catalysts and membranes poisoning. This step is not shown in the layout being neutral to the purpose of the work and common to all the configurations. The auxiliary values adopted for the BoP result from benchmark technologies, typical O&M specifications, requirements for the materials.

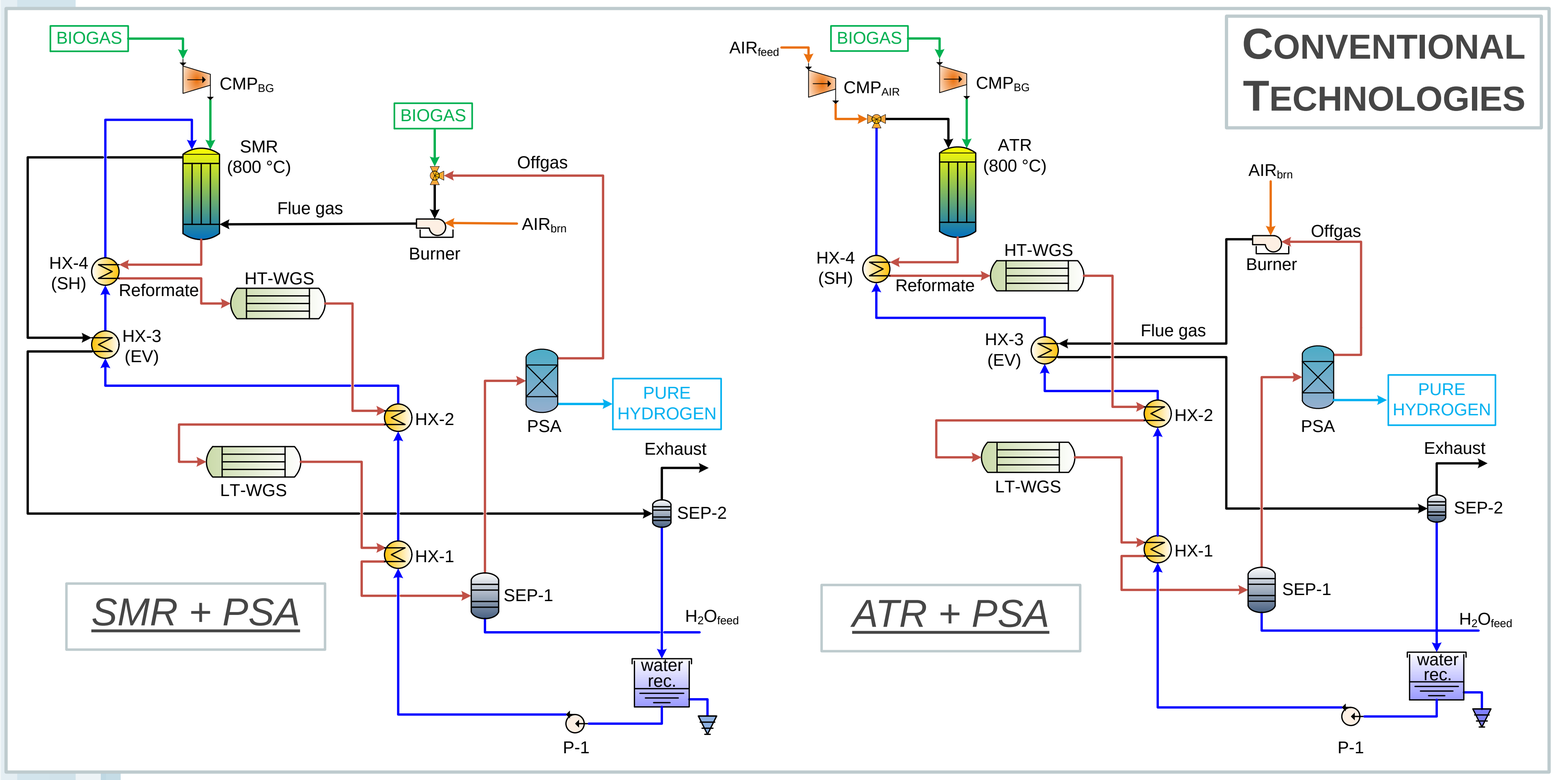
LANDFILL GAS		
	units	values
CH_4	% mol	44.2
CO_2		34
N_2		16
O_2		2.7
CO, H_2		trace
H_2O		Saturated
LHV	MJ/kg	12.7

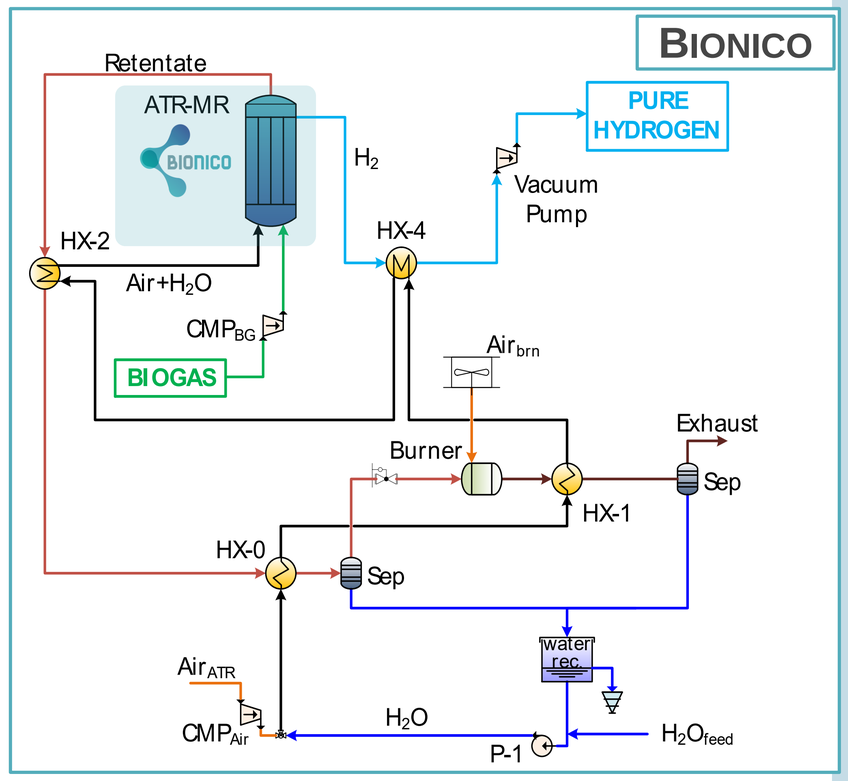
The system efficiency is determined for the three configurations:

$$\eta_{sys} = \frac{\dot{m}_{H_2} LHV_{H_2}}{\left(\dot{m}_{BG_f} + \dot{m}_{BG_{aux}}\right) LHV_{BG} + {W_{aux}}/{\eta_{el,rif}}}$$

- LHV_{H2} is equal to 120 MJ/kg
- W_{aux} is the sum of the electric consumptions of the system auxiliaries (i.e. compressors, pumps, control system)
- $\eta_{el,rif}$ is set equal to 45%, as the average electric efficiency of the power generating park

		CONVENTIONAL		BIONICO
	units	SR	ATR	ATR-MR
Hydrogen mass flow	Kg/day	100	100	100
Max Temperature	°C	800	800	550
Pressure	bar	8-14	8-14	8-14
S/C	-	4	3	3
PSA efficiency	%	78-86	78-86	-
Aux el. efficiency	%	70	70	70





RESULTS & CONCLUSIONS

		REF. TECHNOLOGY		BIONICO
	units	SR	ATR	ATR-MR
Biogas Input	Nm^3/h (kW)	35.7+14.6 (221)	47.0 (207)	36.8 (162)
BG/Air compressors	kW	6.2/-	8.1/11.6	4.4/3.4
Vacuum pump + H_2 compressor	kW	-	-	8.6
System efficiency	$\%_{LHV}$	59.2	55.4	69.2
Membrane Area	m^2	-	-	3.1

Main results show that the BIONICO system efficiency (69.2%) is about 25% and 17% higher with respect to ATR and SMR cases respectively. This record efficiency is reached at a much lower temperature with respect to SMR and ATR thanks to the use of the CMR that allows for hydrogen production and separation in a single step, moving the equilibrium of the reactions towards the products.

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