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Oxy-Gasification
The Use of pure Oxygen in a NOTAR® Gasifier

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Introduction

The **NOTAR®** Gasifier is an industrial multi-stage downdraft Gasifier that produces a **Tar Free syngas**. The technology developed by Xylowatt since 2007 has been demonstrated on 1MWth units on thousands of operating hours coupled to a CHP engine. While NOTAR® gasification has been proving its suitability for electricity production, Xylowatt has been guiding its technological development to fit new market needs.

In particular, Xylowatt directed its development on the production of a high energy syngas, therefore extending the range of application of the NOTAR® technology.

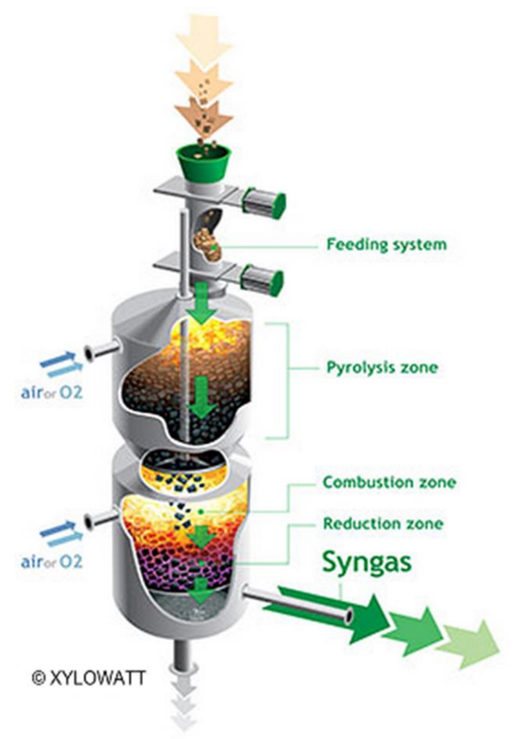

Figure 1: The NOTAR® gasifier

In order to meet industrial gas standards, Xylowatt developed oxy-gasification as the best solution allowing the production of a higher LHV gas at reduced costs. Oxy-gasification is defined as the use of pure oxygen as an oxidizing agent, directly replacing the air process on a NOTAR® reactor; it presents two technical advantages: **the energy content is doubled** due to the elimination of Nitrogen (LHV reaches 10 MJ/Nm3) from the system and the **nominal power of the plant** can be drastically **increased**.

Experimental Setup

Oxy-gasification was initially tested on the TGP – *Test Gasification Plant* – installed at Université Catholique de Louvain la Neuve, Belgium. TGP is a 100-150 kWth NOTAR® Gasifier linked to a gas conditioning unit and offers the possibility to use the syngas in flare, gas engine or boiler. The two-stage Gasifier, illustrated in Figure 2, is composed of a feeding system with sliding valves, a pyrolyzer (above the platform), the combustion zone, (right below the platform), and the reduction section at the bottom of the picture. The gas cleaning unit is not shown in the figure. The plant, when using air, converts up to 45kg/h dry woodchips into syngas.

Oxy-gasification was later tested on a pre-industrial NOTAR® reactor with a capacity, when using air, of 300kg/h dry woodchips, corresponding to around 1MW of LHV in the syngas.

Both plants are equipped with air/oxygen injections in both pyrolysis and combustion zones.
The global oxygen concentration in the air/oxygen mixture injected into the Gasifier is defined as the "**overall enrichment**" of the oxidizing agent.

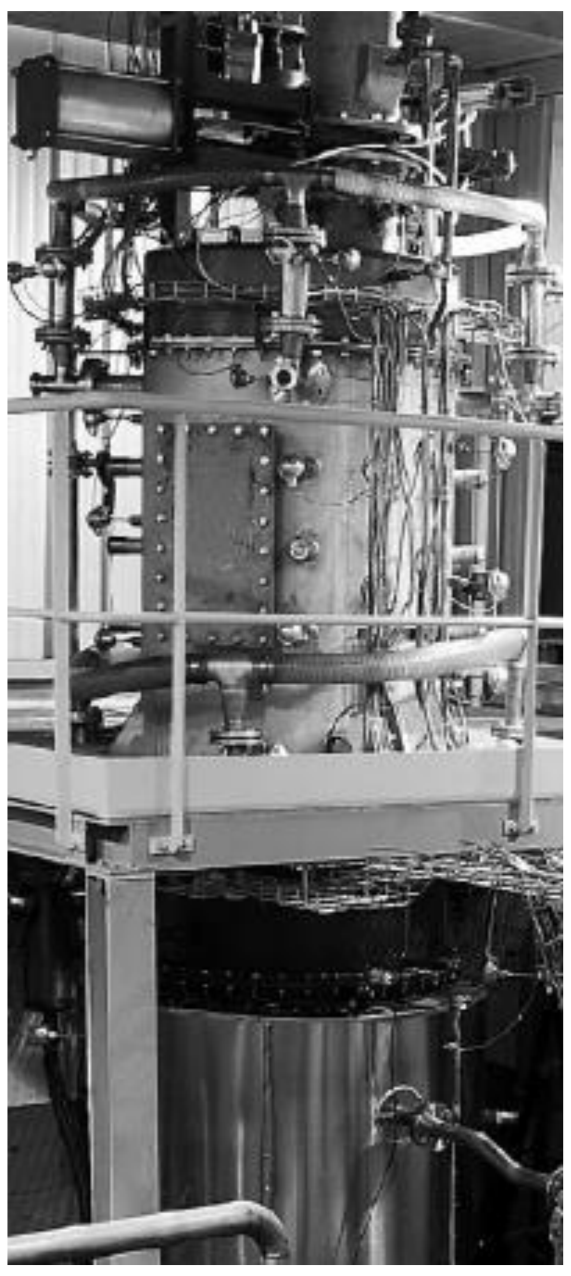

Figure 2: NOTAR® Gasifier on TGP

Oxy-Syngas Composition

Results presented in this section correspond to the data acquisition on both experimental setups.

- Air gasification corresponds to a 21% 'Overall Enrichment'.
- The 100% overall enrichment data are obtained while both pyrolysis and combustion zones are operated with oxygen.

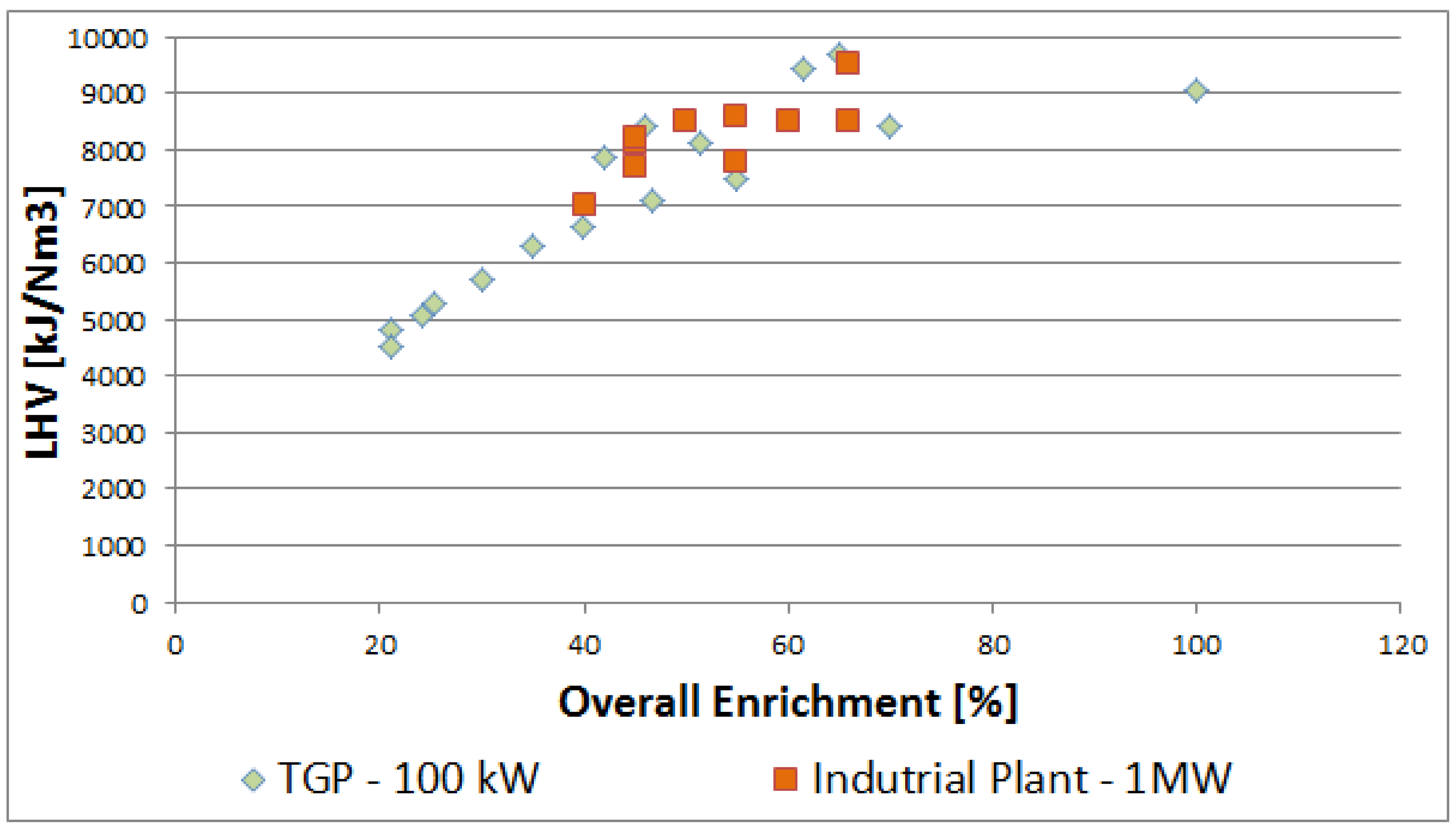

Figure 3: LHV of oxy-syngas obtained for different Overall Enrichments

Figure 3 illustrates that, when increasing overall enrichment, Nitrogen content in the syngas is reduced. Consequently the syngas LHV is increased. Figure 3 also shows that results collected for the 1MWth plant were predicted by TGP tests, confirming the potential on an industrial scale. Higher temperatures reached in the combustion chamber of the reactor enhance the reduction reaction and help increasing LHV and conversion rates. As a consequence, oxy-syngas reaches 9500 kJ/Nm3 at overall enrichments greater than 60%.

		Syngas	Oxy-Syngas	Natural Gas
Overall Enrichment	**%**	**21**	**61**	
CO	%vol	22.5	43.6	
H2	%vol	17.6	34	
CH4	%vol	2	0.8	>90
CO2	%vol	10.5	18.4	
N2	%vol	47.4	3.2	
LHV	MJ/Nm3	5.4	9.5	35.6
V.air	Nm3/Nm3	1.20	2.33	9.50
Air-Gas mix LHV (λ=1)	MJ/Nm3	2.51	3.20	3.41
Gas flow rate (1MW)	Nm3/h	680	390	100
Exhaust gas flow rate (1MW).	Nm3/h	1330	1020	1060

Figure 4: Advantages of oxy-syngas

At comparable nominal power, **oxy-syngas combustion** leads to flue gases that present **similar thermal characteristics** (flue gas flow rate, adiabatic flame temperature) as the flue gases obtained through **natural gas combustion** (Figure 4). It allows quite **direct substitution of natural gas** by oxy-syngas without replacement of flue gas equipments (e.g. heat exchangers). The oxy-gasification innovation allows entering new markets as a high energy gas fits the needs of main industrial applications.

Power increase

The **inner pressure drop** of a downdraft Gasifier is a key operation parameter that defines the **maximum power output**. It is directly related to the syngas flow rate. Thanks to the elimination of nitrogen, the oxy-syngas flow rate is reduced by half at nominal power; drastically decreasing pressure drop on the installation. Tests were performed on the oxygen operated TGP in order to retrieve a pressure drop on the reduction bed equivalent to its initial level while air operated (Figure 5).
Tests resulted in an increase of maximal power of the installation.

TGP, air operated at defined pressure drop has a capacity to convert 45kg/h dry woodchips

TGP, oxygen operated at identical pressure drop (overall enrichment 65%) has a capacity of 90 kg/h of dry woodchips

At equivalent syngas volume flow rates, the **power** of an oxygen operated NOTAR® plant can be **doubled** in comparison to the same Gasifier operated with air.

		Air	O2
Biomass consumption	kg/h	23.3	51.2
Oxidizer			
Air Flow rate	*Nm3/h*	*45*	*19.2*
O2 Flow rate	*Nm3/h*	*-*	*12.2*
Overall Enrichment	*%*	*21*	*51.4*
Syngas Flow rate	Nm3/h	67.6	91
LHV	kJ/Nm3	4527	7459
Power Output	*kW*	85	189

Figure 5: TGP performances at similar pressure drops

References

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