VESTA Methanation Applications for Small Scale, Multipurpose, Green SNG Production

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160+
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Background to Bio-SNG production

► What does “SNG” mean?

**Substitute Natural Gas (SNG)** is the natural gas that can be produced from coal or biomass (Chandel et al., 2009)

► Alternative to expensive natural gas in countries like China where in-house natural gas resources are not present

► Green natural gas
Background to Bio-SNG production

- **Bio-SNG**: one of the most flexible approaches to decarbonize end demand
  - Residential heating (including cooking)
  - Transportation
  - Cogeneration

- A practical pathway to final users
  - Easy connection of production plants to existing natural gas networks
  - Technologies (for gas clean-up, drying, methanation, …) are available and mature for commercial application

- Three alternative renewable pathways
  - Biomass gasification
  - Biogas upgrading
  - Power to Gas
Decree on biomethane to EU’s 2020 goals

Panorama

➢ The biogas sector represents a **production potential of renewable gas by 2030 of 10 billion Nm³ of biomethane** (80% from agricultural matrices and 20% from organic wastes, non-biogenic sources, and gasification).

➢ The production process of biomethane implicates a **reduction of greenhouse gas emissions**.

➢ The previous Legislative Decrees on biomethane (D.M. 5 Dicembre 2013 and D.M. 10 ottobre 2014) have been strongly criticized by the operators of the agro-energy sector due to the lack of success of the provided actions and procedures.

Target

➢ Achievement of the amount of renewable energy sources in the sector of transportation according to **2020 standards**.

Actions

➢ The new decree (March 2018) establishes a **minimum price for the certificates C.I.C.** (Certificati di Immissione in Consumo) derived from the use of advanced biomethane in the **transport sector**.

➢ 10-years guaranteed value equal to 375 €/CIC ~ **75 €/Gcal**
Biomass gasification

Main process blocks: biomass gasification to Bio-SNG

1. **Feedstock preparation**
2. **Gasification**
3. **Tar Removal**
4. **Methanation**
5. **Treatment & Conditioning**
6. **Syngas cooling**

- **ASU** provides **O<sub>2</sub>**
- Syngas cooling removes **CO<sub>2</sub>** and **AG**

Utilities: STEAM/POWER/CW, etc.
Biogas upgrading

Main process blocks: biogas upgrading to Bio-SNG
Power to Gas

Main process blocks: integrated Bio-SNG production from Power to Gas application
Competing technologies:

**Process characteristics:**

1. Recycle compressor to handle the exothermic reactions (a lot of product gases go through circulation, as a heat transfer medium)

2. Complex adjustment of the feed gas to achieve on-spec SNG
Technology review - VESTA

The VESTA technology

Process characteristics:
- No recycle compressor
- CO₂ and H₂O control heat of reaction
- Easy to control
Technology review - VESTA

► Catalyst (high temperature methanation)
  ► Methanation reactors filled with proprietary Clariant catalyst
  ► High stability, robust under different conditions
  ► Suitable for the operating range 230-700 °C (higher than conventional methanation catalysts)
  ► High CO and CO₂ conversion
  ► No carbon deposition
  ► Long operational history and industrial references
  ► Available as pre-reduced catalyst for simple start-up

► Two Basic Design Packages completed

► First License Sold in Europe

► Based on biomass feedstocks
Wood has signed a cooperation agreement with Clariant International AG (“Clariant”) and Wison Engineering Ltd (“Wison Engineering”) to build a pilot plant to demonstrate the Wood VESTA SNG technology.

Pilot plant:

- Designed for a production capacity of 100 Nm$^3$/h of SNG and includes all reactors and control system in order to completely demonstrate a real plant in addition to the verification of the chemical reactions.
- Erected in Nanjing, China.
- Two test campaigns have been carried out in 2014 and 2015/2016 to successfully demonstrate a continuous operation at 100% SNG production meeting the Chinese natural gas grid specification, and to test different operating parameters.
Technology review - VESTA

► Methanation: VESTA Pilot Plant

Pilot plant and methanation reactors
Methanation: Bio-SNG demonstration plant

The 4.5 MWh Biomass-to-SNG Demonstration Project will establish the commercial feasibility of the Bio-SNG process in the next few months.

Funded by the UK’s Department for Transport and by National Grid Gas Distribution.

Advanced Plasma Power’s Gasplasma® technology to convert biomass to syngas followed by Wood’s VESTA SNG technology to convert syngas to substitute natural gas (SNG).

The Biomass-to-SNG Demonstration scope consist of a Basic Engineering Design (BED) followed by Engineering Procurement & Fabrication (EPF) which includes the following sections:

- Final gas clean-up (deep desulphurisation, dehalogenation)
- Clean syngas methanation
- CO₂ removal system
- SNG drying

Wood sections are mechanically completed, while the commissioning of the upstream section are ongoing. Expected start-up date: end of September.
Techno-economic assessment of Biomass-to-SNG

Case study #1: Biomass gasification to Bio-SNG production

Main Input Data
Feedstock: Woody materials
Outlet thermal power (SNG): 200 MWh
(or 21,000 Nm³/h)

Plant Configuration
CFB Gasifier pressurized and oxygen blown
Catalytic tar reforming
Physical solvent washing for H₂S removal
VESTA SNG Technology
Chemical solvent washing for CO₂ removal

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<tr>
<th>ITEM</th>
<th>VALUE</th>
<th>UNIT</th>
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<tbody>
<tr>
<td>Inlet thermal power</td>
<td>315-330</td>
<td>MWh</td>
</tr>
<tr>
<td>Efficiency (SNG thermal power / Biomass thermal power)</td>
<td>Up to 67</td>
<td>%</td>
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<tr>
<td>SNG production cost (Biomass cost 22 €/ton; Full Equity, I.R.R. 8%)</td>
<td>13.0</td>
<td>$/MMbtu</td>
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Techno-economic assessment of Biogas-to-SNG

► Case study #2: Biogas upgrading to Bio-SNG production

► Main Input Data

Feedstocks: 3 MWh Biogas
550 Nm\(^3\)/h Renewable Hydrogen

Outlet thermal power (SNG): 4.4 MWh

► Plant Configuration

Electrolyzers for Hydrogen generation
Desulphurization (biological or chemical)
VESTA SNG Technology

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<td>Electrical power required for renewable hydrogen production</td>
<td>2.3</td>
<td>MW</td>
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<td>Outlet SNG flowrate</td>
<td>455</td>
<td>Nm(^3)/h</td>
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<td>Electrical power to SNG efficiency</td>
<td>61</td>
<td>%</td>
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Techno-economic assessment of Power to Gas-to-SNG

► Case study #3: Power to Gas application to Bio-SNG production

► Main Input Data

Feedstocks: 141 Nm³/h CO₂
550 Nm³/h Renewable Hydrogen

Outlet thermal power (SNG): 4.4 MWh

► Plant Configuration

Electrolyzers for Hydrogen generation

VESTA SNG Technology

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<td>Electrical power required for renewable Hydrogen production</td>
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<td>Outlet SNG flowrate</td>
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<td>Nm³/h</td>
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<td>Electrical power to SNG efficiency</td>
<td>60</td>
<td>%</td>
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Conclusions

► SNG production via biomass gasification, biogas and Power to Gas applications has been proved to be technically feasible.

► Considering a middle term forecast for the natural gas price of 8-10 $/MMBtu the biomass gasification plant can be economically attractive with an incentive in line with what currently applies in Northern Europe, or alternatively considering a monetization for the low level heat integration (e.g., district heating).

► New Italian decree on biomethane provides a strong potential to biofuel production to meet “2020 goals” by recognizing the value of the C.I.C.

► Main technologies are available and mature for commercial application.

► Wood is strongly committed in this field, being technology leader, together with Clariant, of a patented SNG production process (VESTA) that can be applied to shape the future of clean energy.
Thank you

G.Collodi
guido.collodi@woodplc.com

L. Mancuso
luca.mancuso@woodplc.com

F. Ruggeri
fabio.ruggeri@woodplc.com

V. Depetri
valentina.depetri@woodplc.com

For VESTA enquiries, please contact
SNG@amecfw.com

Questions and Answers?!