

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

Amec Foster Wheeler Italiana (a Wood Company)

Wood in short

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Operating in more than 60 countries

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Over 160 years experience

Wood in short

we are everywhere you need us

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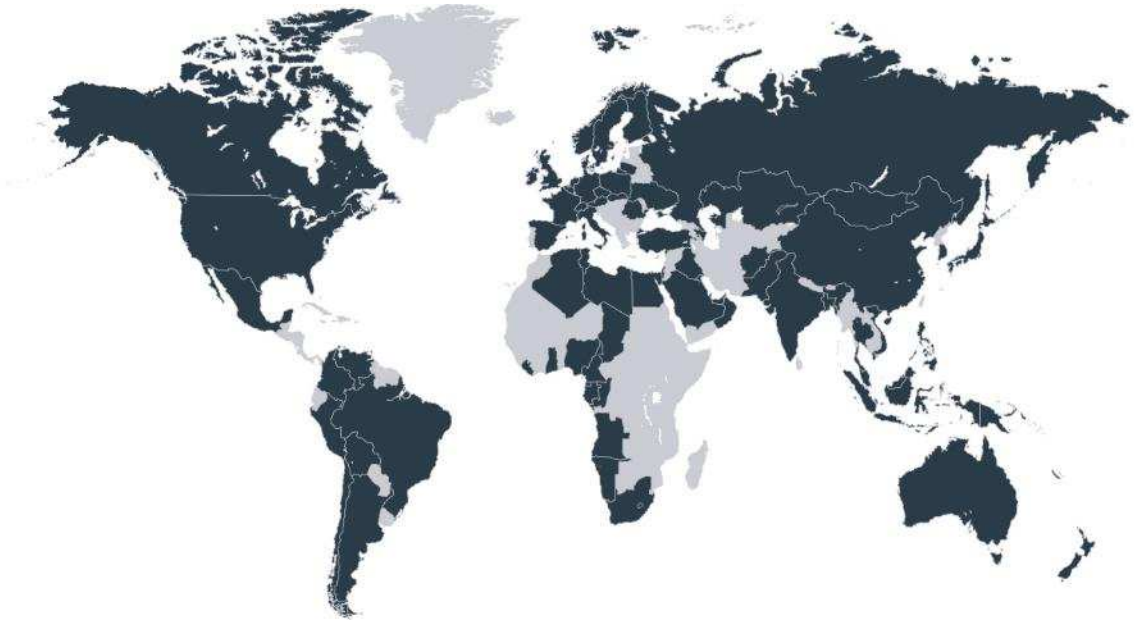
- We’re accelerating and expanding in new sectors and geographies
- Unlocking our technology across an incredible sector spread



More than 400 offices worldwide

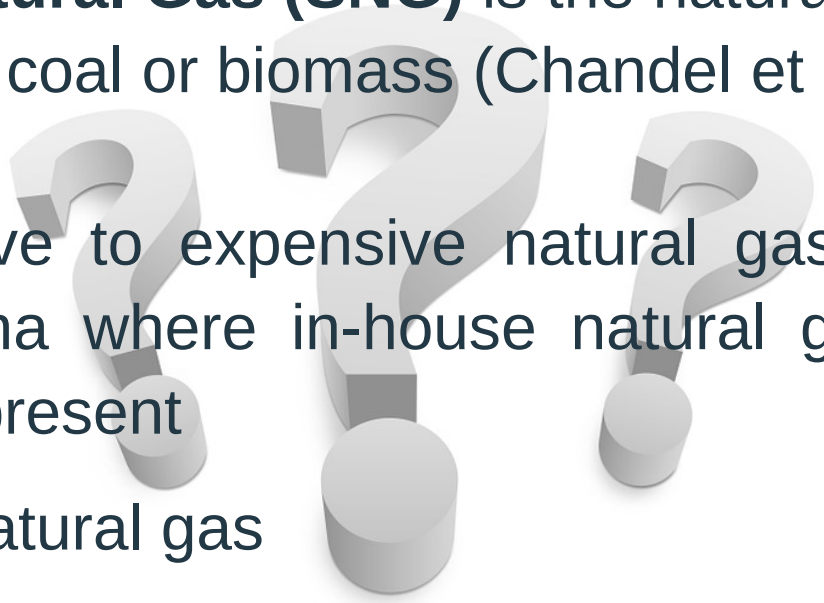
Contents

- Introduction to Bio-SNG production
- Decree on Biomethane
- Alternative process schemes of Bio-SNG production
- Methanation brick: VESTA technology
- Techno-economic assessment of the alternative process schemes
- Conclusions

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 Nm^3 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

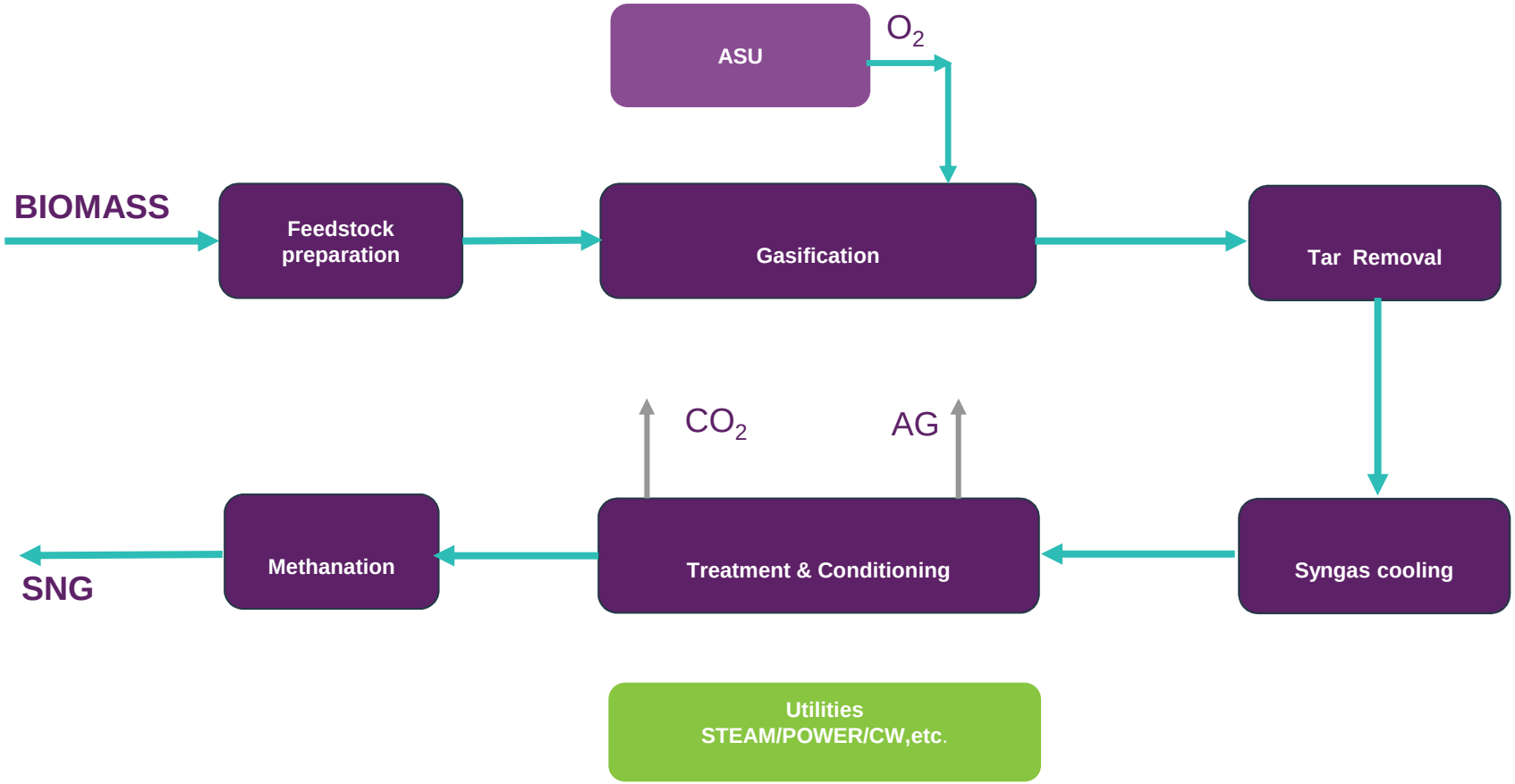
- Achievement of the amount of renewable energy sources in the sector of transportation according to **2020 standards**.

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**

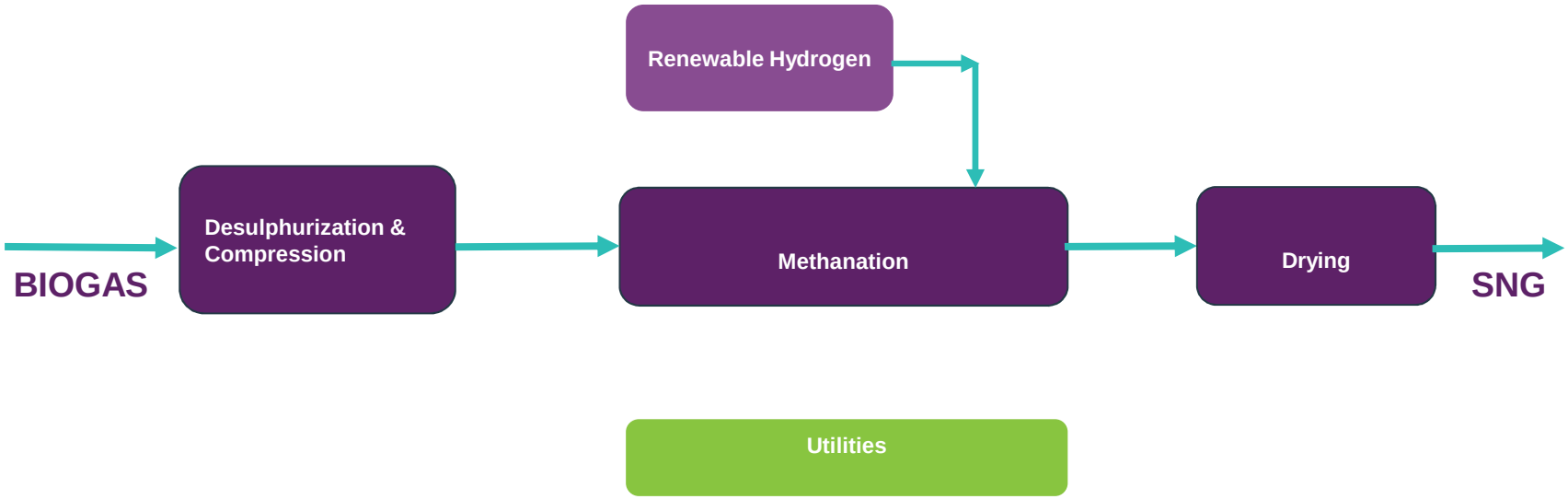
Biomass gasification

Main process blocks: biomass gasification to Bio-SNG



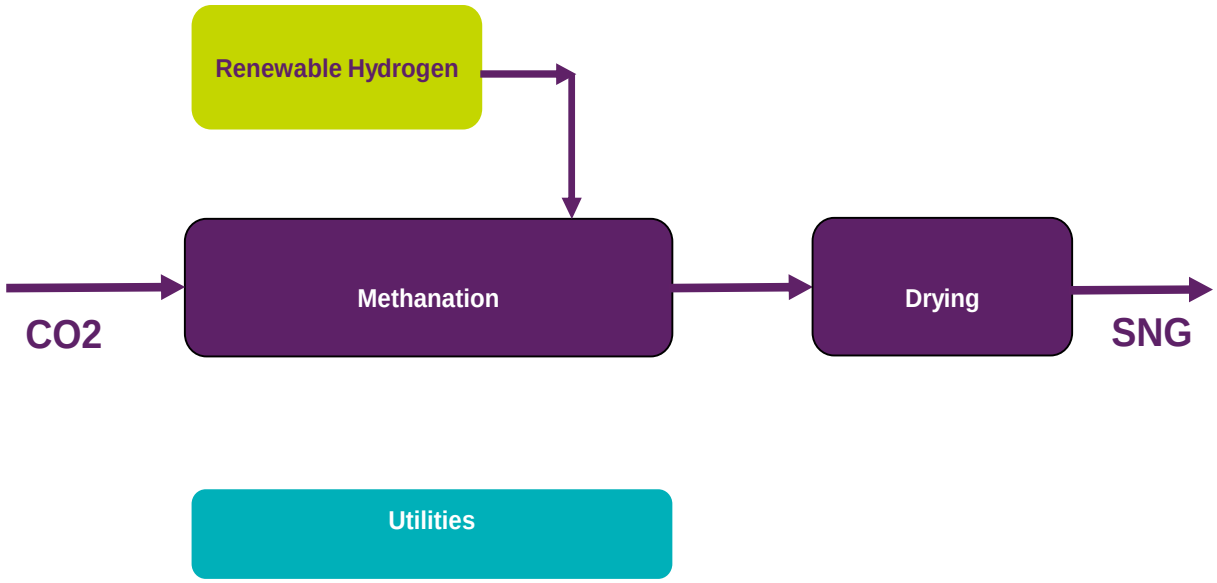
Biogas upgrading

Main process blocks: biogas upgrading to Bio-SNG



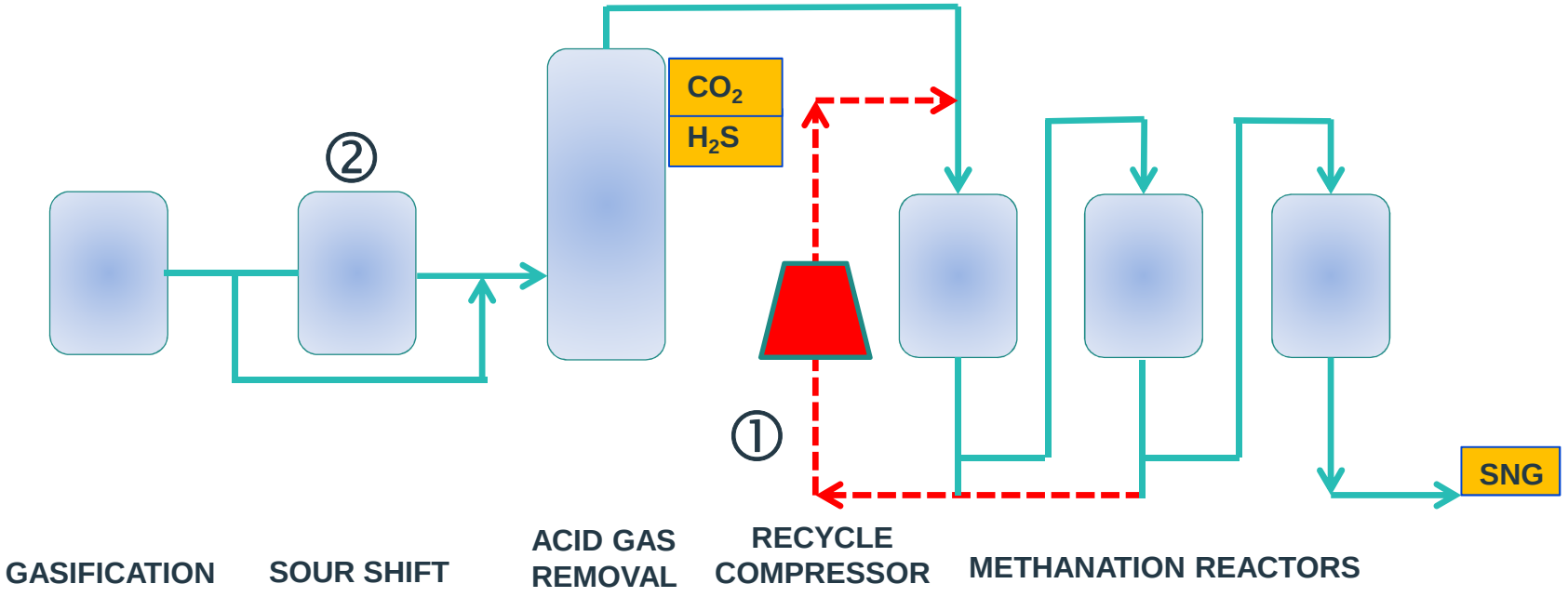
Power to Gas

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



Technology review - VESTA

- Competing technologies



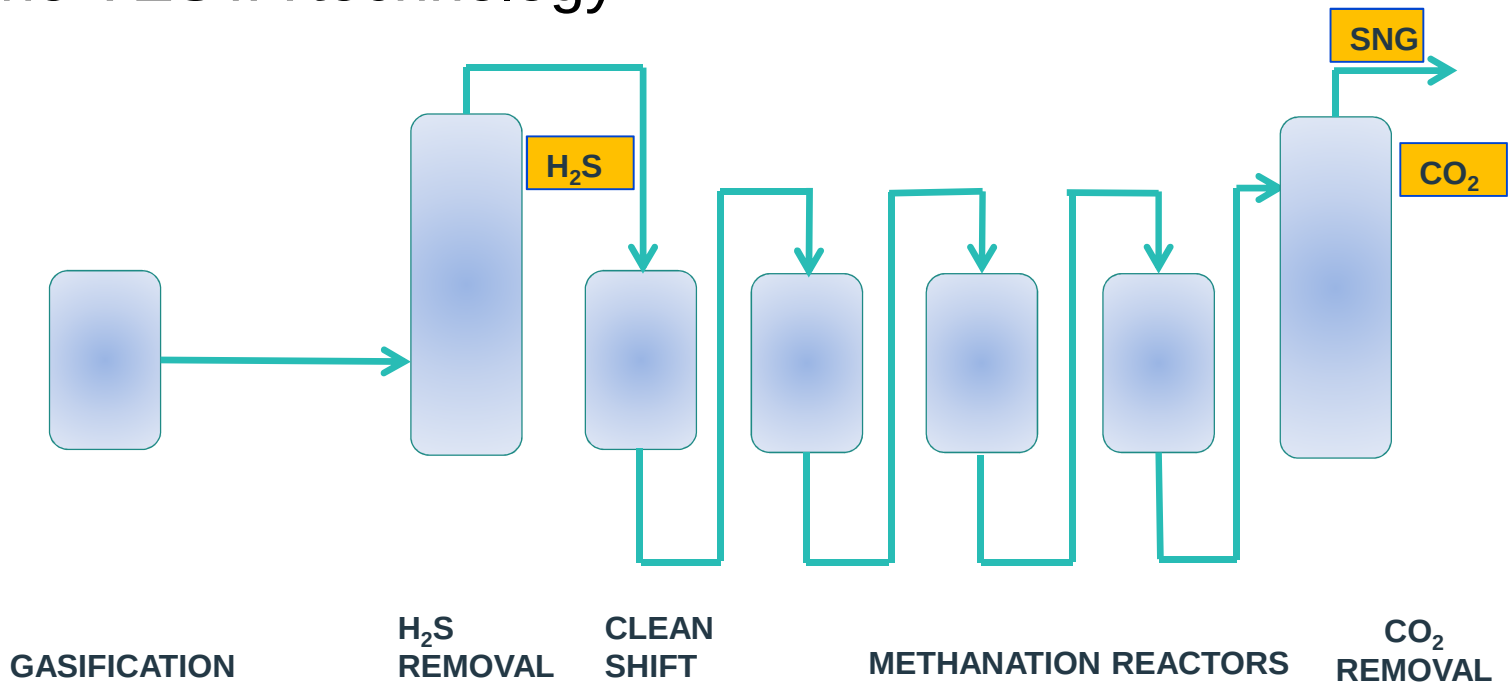
Process characteristics:

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
- CO_2 and H_2O 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 CO_2 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

Technology review - VESTA

- 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

Technology review - VESTA

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

Advanced Plasma Power Swindon plant

- 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
  - CO_2 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

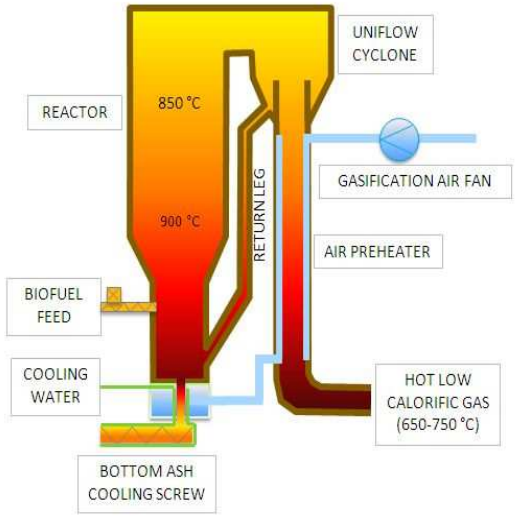
Case study #1: Biomass gasification to Bio-SNG production

Main Input Data

Feedstock: Woody materials

Outlet thermal power (SNG): 200 MWh

(or 21,000 Nm^3/h)



Plant Configuration

CFB Gasifier pressurized and oxygen blown

Catalytic tar reforming

Physical solvent washing for H_2S removal

VESTA SNG Technology

Chemical solvent washing for CO_2 removal

ITEM	VALUE	UNIT
Inlet thermal power	315-330	MWh
Efficiency (SNG thermal power / Biomass thermal power)	Up to 67	%
SNG production cost (Biomass cost 22 €/ton; Full Equity, I.R.R. 8%)	13.0	$/MMbtu

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

ITEM	VALUE	UNIT
Electrical power required for renewable hydrogen production	2.3	MW
Outlet SNG flowrate	455	Nm^3/h
Electrical power to SNG efficiency	61	%

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 Nm^3/h CO_2

550 Nm^3/h Renewable Hydrogen

Outlet thermal power (SNG): 4.4 MWh

Plant Configuration

Electrolyzers for Hydrogen generation

VESTA SNG Technology

ITEM	VALUE	UNIT
Electrical power required for renewable Hydrogen production	2.3	MW
Outlet SNG flowrate	145	Nm^3/h
Electrical power to SNG efficiency	60	%

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

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Questions and Answers?!