La conversione delle biomasse in vettore energetico primario: Il gas naturale

LE BIOMASSE COME VETTORE ENERGETICO: QUALI PROSPETTIVE
Convegno ATI; Milano 20 Aprile 2016
Why biomass gasification? Why SNG?

► Introduction: why biomass and SNG?

► SNG: a practical pathway to final users
  ► Easy connection of production plants to existing NG networks
Plant overview

Main process blocks

- **Biomass**
  - Feedstock preparation
  - Gasification
  - Tar Removal

- **Syngas**
  - ASU
  - O₂

- **Utilities**
  - CO₂
  - AG
  - Steam/Power/CW, etc.

**SNG**

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Gasification: Amec Foster Wheeler CFB Gasifier

- 11 gasifiers built in 1981-2008
- Readiness to offer plants for over 100 MWth air-blown applications for various wood and waste based fuels
- Readiness to offer pressurized oxygen-steam blown gasifiers up to ~300 MW for biorefinery applications with wood based fuels
- Process conditions according to fuels and applications

Long History (originally developed end 70’s/beginning 80’s) → Recent commercial applications → New developments in progress
Technology review - Gasification

Gasification: Varkaus 12 MWth O2-H2O Demo plant and 5 MWth slip stream
Gasification: Varkaus 12 MWth O2-H2O Demo plant and 5 MWth slip stream

Test runs included testing at different gasification temperatures ranging from 860 to 940 °C and different oxygen/steam ratios.

The fuel consisted of different types of woody biomass: wood chips, first felling wood, bark and forest residues.

The cumulative operation hours of the oxygen-steam gasification exceeded 9,000 by the beginning of June 2011 with more than 90% reliability.
## Tar removal: Features of TAR removal processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Risk</th>
</tr>
</thead>
</table>
| Aqueous Scrubbing     | ▪ Good efficiency
▪ Smooth and trouble-free operation                                    | ▪ Tars pass from gas to liquid phase
▪ High Capex for WWT                                                        | ▪ Light tars in the clean syngas                                              |
| Thermal Cracking      | • Complete removal
• Chemical energy remains in syngas                                       | ▪ Soot formation
▪ High Capex
▪ Low thermal efficiency (product used to provide heat)                     | ▪ None                                                                            |
| Catalytic Cracking    | • Potential complete removal
• Chemical energy remains in syngas
• Composition of product gas can be adjusted                                | ▪ Soot formation
▪ Catalyst consumption and cost
▪ Catalyst disposal due to Ni                                                 | ▪ Coke formation and catalyst deactivation
▪ Low references                                                            |
| Oil Scrubbing         | • Stability and availability
▪ Chemical energy remains in syngas (tars recycle)
▪ High efficiency                                                          | ▪ Scrubber/Stripper to remove NH₃, HCl, H₂S
▪ High level of filtration at high temperature                              | ▪ Naphtalene in the clean syngas: test required                               |
SNG VESTA Technology:

- The competing technologies

Process characteristics:

1. Recycle compressor to handle the exothermic reactions
2. Complex adjustment of the feed gas to achieve in-spec SNG
SNG VESTA Technology:

- The VESTA technology
  - No recycle compressor
  - CO2 and H2O control heat of reaction
  - Easy to control

VESTA is a simple, safe and reliable process
Technology review - VESTA

- Methanation: VESTA Technology Highlights
  - No recycle of CH4 product to the syngas
  - Dilute with CO2
  - Dilute with Water
  - Dilution with CO2 and Water
    - No Recycle Stream
  - Temperature can not exceed 550°C
    - No uncontrolled reaction possible
  - Flexibility of syngas composition
    - No need for sour gas shift (SGS)
SNG VESTA Technology:

► The catalyst

**Advantages:**

- high stability, robust under different conditions
- high CO and CO2 conversion
- No carbon deposition
- long operational history and industrial references
- available as pre-reduced catalyst for simple start-up
Technology review - VESTA

► Methanation: VESTA Pilot Plant

Amec Foster Wheeler has signed a cooperation agreement with Clariant International AG (“Clariant”) and Wison Engineering Ltd (“Wison Engineering”) to build a pilot plant to demonstrate the Amec Foster Wheeler VESTA Substitute Natural Gas (SNG) technology.

The pilot plant:

► Designed for a production capacity of 100 Nm3/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 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 methanation reactors
SNG VESTA Technology:

- **Methanation: VESTA Pilot Plant**

  Pilot plant distributed control system

  Pilot plant catalyst replacement
SNG VESTA Technology:

- Temperature profile first methanator

![Catalyst T profile of R-002A](image)
Biomass-to-SNG: Case study

Case study: Biomass to SNG

Main Input Data

Feedstock: Woody materials
Outlet thermal power (SNG): 200 MWth (or 21,000 Nm³/h)

Plant Configuration

Amec Foster Wheeler CFB Gasifier pressurized and oxygen blown
Catalytic tar reforming
Physical solvent washing for H₂S removal
VESTA SNG Technology
## Biomass-to-SNG: Case study

### Case study: Biomass to SNG

<table>
<thead>
<tr>
<th>ITEM</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock type</td>
<td>Woody material</td>
<td></td>
</tr>
<tr>
<td>Feedstock flowrate</td>
<td>130</td>
<td>t/h AR</td>
</tr>
<tr>
<td>Inlet thermal power</td>
<td>315-330</td>
<td>MWth</td>
</tr>
<tr>
<td>Outlet SNG flowrate</td>
<td>21,000</td>
<td>Nm3/h</td>
</tr>
<tr>
<td>Outlet Thermal power</td>
<td>200</td>
<td>MWth</td>
</tr>
<tr>
<td>Biomass to SNG efficiency (Ther. Power bases, including biomass for power production)</td>
<td>60-63.....67</td>
<td>%</td>
</tr>
<tr>
<td>Total Investment Cost (TIC)</td>
<td>340-370</td>
<td>M€</td>
</tr>
<tr>
<td>Specific Total Investment Cost (TIC / Ther. power out)</td>
<td>1,700-1,850</td>
<td>€/kWth SNG</td>
</tr>
<tr>
<td>SNG production cost (Biomass cost 22 €/ton; Full Equity, I.R.R. 8%)</td>
<td>13.0</td>
<td>$/MMbtu</td>
</tr>
</tbody>
</table>
Conclusions

► SNG production via biomass gasification is technically feasible; main technologies are available and sufficiently mature for commercial application.

► Considering a middle term forecast for the natural gas price of 8-10 $/MMBtu the 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).

► Amec Foster Wheeler is strongly committed in this field, being technology leader and owner for the biomass gasification process through its proprietary CFB-based gasification technology and, together with Clariant, of a patented and novel SNG production process (VESTA).