Who we are
Amec Foster Wheeler at a glance

Market mix by revenue
- Mining: 7%
- Environment & Infrastructure: 12%
- Clean Energy: 27%
- Oil & Gas: 54%

Business units
- Americas, Northern Europe & CIS (NECIS), Asia, Middle East, Africa & Southern Europe (AMEASE), Global Power Group (GPG)
- Consultancy, engineering, project management, operations and construction services, project delivery, specialised power equipment

Waste-to-Product / Gasification experience
- 160+ year history
- FEED and EPC for Tees Valley Energy from Waste Project in UK
- Track history in design and construction of conventional incinerators
- 40+ gasification studies and pre-FEEDs
- 4 gasification FEEDs
- 370+ Amec Foster Wheeler Circulating Fluidised Bed (CFB) boilers in operation worldwide
- ~225 GWe of installed generating capacity on five continents

Amec Foster Wheeler
Trading symbol AMFW

36,000 people worldwide
£5.5bn Revenue
~225 GWe of installed generating capacity on five continents
Waste Gasification to SNG scheme

- **Waste**
  - FEEDSTOCK PREPARATION & DRYING
  - Gasplasma Process
  - Syngas Cooling & Cleaning
  - Syngas Compression
  - Syngas Polishing
  - CO₂ Removal
  - CO₂ to Atm or Storage

- **Carbon Dioxide**
  - To Atmosphere or Storage

- **Oxygen**
  - From Air Separation Unit
  - To Gasifier

- **Steam**
  - To MSW Drier & Gasifier
  - To Gasifier

- **Slag & Metal**
  - From Gasplasma Process

- **Syngas**
  - From Gasplasma Process
  - To Syngas Compression
  - To Syngas Polishing
  - To CO₂ Removal
  - To SNG Drying

- **SNG**
  - From SNG Drying

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Introducing Advanced Plasma Power

Advanced Plasma Power (APP) is a UK-based global pioneer in advanced waste-to-energy and fuels technology employing the internationally patented Gasplasma® technology

Founding plasma company, Tetronics International established in Oxfordshire, UK in 1964 to supply world leading DC Plasma technology

Tetronics Plasma technology a key component in the APP Gasplasma® process

APP formed in 2005 to develop and commercialise the globally patented Gasplasma® technology

Pilot plant operated from 2005, demonstration plant from 2008

APP’s offering includes Gasplasma® process followed by syngas cooling & cleaning producing engine quality clean syngas
The Gasplasma® process is an innovative combination of two well-established technologies, both of which have decades of proven commercial operation:

1. **Gasification**

2. **Plasma Conversion**

Exceptionally Clean Syngas

*Treating waste as a resource*
Advanced Plasma Power - Technology

The Gasplasma® Cycle
Syngas Polishing

The clean syngas from the gasification island needs further polishing to meet the inlet specification of the downstream catalytic SNG process. The syngas polishing section has been designed using adsorbent / catalytic steps required for specific contaminants.

Following are typical polishing steps required for VESTA SNG catalytic process using municipal solid waste as feedstock:

- **Dehalogenation**: Using adsorbent which acts as a guard bed for traces of residual HCl and other halogen contaminants in the syngas

- **Hydrogenation**: Using catalyst which promotes the hydrogenation of residual olefins and sulphur compounds in the syngas

- **Desulphurisation**: Using adsorbent which acts as a guard bed for H$_2$S; reducing the total sulphur content to ~10 ppb to avoid poisoning of downstream catalysts
Innovative VESTA methanation technology produces Substitute Natural Gas (SNG) from gasification of fuel such as Waste, Biomass, Coal, Petroleum coke etc.

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

VESTA is a simple, safe and reliable process
Catalytic methanation process:

Methanation reactors filled with proprietary Clariant catalyst.

The catalyst has a higher conversion rate and wider operating temperature range (230-700°C) than conventional methanation catalysts.

Long operational history and industrial references.

Flexibility of syngas composition:

Substitute natural gas (SNG) production is easy to operate and does not require strict control of the hydrogen / carbon ratio.

The product quality is therefore more stable and reliable.

No need for sour gas shift.
VESTA Highlights

Once-through operation:

CO$_2$ and water in syngas control the exothermic heat of reaction.

No recycle of CH$_4$ product to the syngas required: dilute with CO$_2$ and water.

No need for expensive recycle compressors or refractory-lined reactors, reducing capital expenditure.

No uncontrolled reaction possible.

Full flexibility to balance CAPEX / OPEX (methanators outlet temperature, HP steam production).

VESTA provides significant capital and operational expenditure savings for customers
Amec Foster Wheeler has signed a cooperation agreement with Clariant International AG and Wison Engineering Ltd to build a pilot plant to demonstrate the Amec Foster Wheeler VESTA technology.
The pilot plant:

Designed for a production capacity of 100 Nm$^3$/h of SNG.

Includes all reactors and control system in order to completely demonstrate a real plant in addition to the verification of the chemical reactions.

Feedstock: Syngas from Coal Gasification.

Erected in Nanjing, China.

Two test campaigns have been carried out in 2014 and 2015/2016 to demonstrate continuous operation at 100% SNG production, meeting the Chinese natural gas grid specification, and to test different operating parameters.
Study basis

~1700 tpd of raw municipal solid waste (MSW) to the plant boundary

Location – North East UK Region

Feedstock preparation for gasification process: Material Recycling Facility followed by drying to meet feed specification

~1000 tpd of processed municipal solid waste

Feedstock drying to meet feed specification for APP Gasplasma® Process

Plant availability: 85% or 7,446 hours/year

Project life 25 years
### Technical Performance Data

<table>
<thead>
<tr>
<th></th>
<th>MSW Gasification to SNG</th>
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<tbody>
<tr>
<td>Raw MSW</td>
<td>71 tph</td>
</tr>
<tr>
<td>Processed MSW</td>
<td>42 tph</td>
</tr>
<tr>
<td>Dried MSW</td>
<td>28 tph</td>
</tr>
<tr>
<td>Syngas</td>
<td>33 tph</td>
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<tr>
<td>SNG product</td>
<td>7,700 Nm³/h</td>
</tr>
<tr>
<td>Thermal flow of Processed MSW</td>
<td>129 MW</td>
</tr>
<tr>
<td>Thermal flow of dry MSW to Gasifier</td>
<td>120 MW</td>
</tr>
<tr>
<td>Thermal flow of syngas to VESTA</td>
<td>102 MW</td>
</tr>
<tr>
<td>Thermal flow of SNG</td>
<td>80 MW</td>
</tr>
<tr>
<td>Overall Thermal Conversion Efficiency Waste to SNG</td>
<td>62 %</td>
</tr>
</tbody>
</table>
## Economic Data

<table>
<thead>
<tr>
<th>Waste Gasification to SNG</th>
<th></th>
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<tbody>
<tr>
<td>Total Installed Cost Estimate, MM£</td>
<td>200</td>
</tr>
<tr>
<td>CAPEX Intensity, MM£/MW of SNG</td>
<td>2.5</td>
</tr>
<tr>
<td>Assumed £ to $</td>
<td>1.3</td>
</tr>
<tr>
<td>CAPEX Intensity, MM$/MW of SNG</td>
<td>3.3</td>
</tr>
</tbody>
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<tr>
<th>Revenue Stream (2016 Basis)</th>
<th>Waste Gasification to SNG</th>
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<tbody>
<tr>
<td>Average MSW Tipping Fee (UK)</td>
<td>£70 / t</td>
</tr>
<tr>
<td>UK Government Incentive (RTFC)</td>
<td>£37 / MWh</td>
</tr>
<tr>
<td>SNG selling price (UK)</td>
<td>£15 / MWh</td>
</tr>
</tbody>
</table>
Typical schedule for a Waste Gasification to SNG Fuel project:

- **Pre-FEED**: 4 Months
- **FEED**: 6 Months
- **EPC**: 2.5 Years
APP & Amec Foster Wheeler
Biomass-to-SNG Demonstration Plant

Go Green Fuels, Swindon, UK

Project overview
Biomass to SNG project is funded by Department of Transport, UK as part of a programme to develop and commercialise technologies required to decarbonise the transport sector. The 4.5 MWth demonstration plant will produce enough compressed SNG to power 75 heavy goods vehicles. The overall process will use Advanced Plasma Power’s Gasplamsa® technology to convert biomass to syngas followed by Amec Foster Wheeler’s VESTA SNG technology to convert syngas to substitute natural gas (SNG).

Scope
Basic Engineering Design (BED) followed by Engineering Procurement & Fabrication (EPF) of Amec Foster Wheeler’s VESTA SNG technology which includes the following sections:
- Final gas clean-up (deep desulphurisation, dehalogenation)
- Clean syngas methanation
- CO₂ removal system
- SNG drying
Paper written by:
Dr Ruby Ray
ruby.ray@amecfw.com
Rolf Stein
rolf.stein@app-uk.com

Presented by:
Kevin Bunten
kevin.bunten@amecfw.com

For VESTA enquiries, contact:
Fabio Ruggeri
fabio.ruggeri@amecfw.com

amecfw.com