Towards 2\textsuperscript{nd} generation of IGCC plants

Nuon Magnum multi-fuel power plant

Robert de Kler, May 2009
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Why Gasification

- Replacement of existing old assets
- Gasification is one of the most versatile and clean ways to generate energy from solid and/or liquid fuels
- Multi product in and out
- Emissions are lower compared to conventional coal plants and gasification has the possibility to capture CO₂ relatively efficiently

Opportunity to implement a phased approach with a much lower CO₂ footprint

Nuon is building on the Buggenum experience

Buggenum is the first fully integrated gasification plant with a Combined Cycle. The unit was commissioned in 1994. During its first years Buggenum served as a demonstration plant up to 2001 when it smoothly switched into commercial operations. In the time span 2001-2004 the unit operated predominately as a swing unit, optimising Nuon’s power position (long or short). From 2005 onwards the unit is fuelled with biomass up to 30% (mass) base.
Today's plant of the future

- CO2 emission level equivalent to modern gas-fired CCGT
- Bulk Removal
- Minimal energy consumption
- Storage in deplete gas field
Phased approach of Nuon Magnum is an innovative way to be capture ready, and create a low CO₂ footprint:

**Phase I**

Modern state-of-the-art combined cycle on natural gas with a low CO₂ emission, but ready for syngas!

**Phase 2**

Multi fuel gasification, which allow for application of:

- CO₂ capture via well proven pre-combustion technology;
- Co-gasification of biomass up to 40-50 m%;

- CO₂ emission levels lower than natural gas plants
- Capture ready with a 50% lower CO₂ foot print compared to conventional boilers
Since the start of the Magnum project the CO₂ capture installation has been developed and integrated in the Magnum Design. Relevant design adjustments have been adapted to Nuon Magnum plant such as: Gas Turbine capabilities, Material selection, Gas purification, Sweet versus sour shift, Wet quench versus Syngas cooler.

Capture readiness is not limited to reserving plot space!
Multi-product approach for Magnum

**Inputs**
- Coal
- Biomass
- Sec. fuels
- Nat. gas

**Assets**
- ASU
- Gasification
- CO Shift
- CCU
- Power

**Products**
- $O_2$
- $N_2$
- Syngas
- $CO_2$
- $H_2$
- SNG
- Heat

**Clients**
- Eemsmond Industry
- NG Q-conversion
- EOR, Storage
- Pipeline; Pub. Transp.
- Greenhouses, Local ind., LNG
Status

Design optimizations phase II

Magnum phase II scoping study in progress. The objective is to optimize and integrate CCS in the design of the Gasification section (gas treatment units) in line with latest technology insights. For this, the pilot test in Buggenum will be used as a very important design verification.
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Pilot Plant and R&D program
Why pre-combustion pilot tests

Very important design verification

- Identify and mitigate potential risks
- Prepare for large-scale application in Nuon Magnum
- Testing new technologies
Main test objectives

- Measurement and optimisation of plant performance
- Water balance control needs to be checked
- Dynamic operation (specific for the power industry)
- Syngas quality changes due to feedstock changes
- Measure catalyst deactivation
- Assess solvent foaming and entrainment
- Direct water injection may cause corrosion
Prepare for Nuon Magnum (1)

- Define the optimal product quality and yields
- Select the optimal catalyst for the desired conversion rate and lifetime
- Select a solvent (solvent mixture?) for the optimal capacity, selectivity, and minimal foaming
- Select the optimal packing type (structured vs. random) and size depending on desired capture rate and solvent capacity
Prepare for Nuon Magnum (2)

- Select the optimal trade-off for capture rate vs. energy consumption
- Scale the shift reactors and the absorber for optimal conversion rate and capture rate with minimal CAPEX
- Indicate the main corrosion-prone locations and select optimal materials
- Define maintenance intensive plant parts and establish optimal maintenance procedures
Testing new technologies

- New high temperature catalysts resulting in lower H₂O:CO ratio (range 2.0-3.0) and higher outlet temperature (up to 590 °C)

- Various shift reactor configurations (with gas quench possible after each reactor, quench temperature range of 150-183 °C)

- New solvents in wide operating temperature range (20-80 °C) and pressure range (21-23 bar)

- Nano-filtration unit to separate solvent and H₂O to control water balance

More novel pre-combustion tests

The pilot plant has been designed as such that a wide range of tests can be adapted later (tie-ins, plot space). Institutes could use this opportunity to test novel technologies at real IGCC conditions.
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Pilot Plant and R&D program
Circa 0.34 kg/s (0.8%) taken from the main syngas stream
Equivalent to CO$_2$ capture of circa 10,000 t/yr
Visualization CO₂ Catch-up pilot plant
Timeline

- **Basic Engineering**
  - 2008: Q1 Basic Engineering Package

- **Detailed Engineering**
  - 2009: Q2 Start of construction

- **Realization**
  - 2009: Q4 Design Nuon Magnum
  - 2010: Q4 Start of testing

- **Operation/Testing**
  - 2010: Q4 End of testing
  - 2011: Q1

- **Decommissioning**
  - 2012: Q1

- **R&D programme**
  - 2008: Q2 Signing contract R&D partners

**Scoping** | **Definition** | **Execution** | **Operation**
Research & Development Programme

Work Package 1: Plant operation and optimization

Work Package 2: Water gas shift section

Work Package 3: CO₂ Absorption section

Work Package 4: Fouling and corrosion
Thank you!