SCR retrofit in a 100% wood-fired power plant
The Rodenhuize case

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Yves Ryckmans
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AGENDA

• Laborelec

• The pathways to biomass retrofit

• GDF SUEZ case studies

• The different approaches to reduce NOx emissions

• The challenges of SCR technology with biomass

• Conclusion
LABORELEC: expertise centre within GDF SUEZ

- 250 researchers and technical specialists
- Non-profit cooperative company
- Turnover € 47M
- 25% of turnover outside GDF SUEZ
The pathways to biomass retrofit: fuel

- Availability
  - Origination of biomass
  - Selection on sourcing, availability & logistics

- Sustainability
  - Selection available on sustainability criteria
  - Selection on local stakeholders

- Applicability
  - Sample lab testing on chemical & physical comp.
  - Selection on technical applicability

- Feasibility
  - Selection on commercial feasibility
  - Integrated in business modeling
The pathways to biomass retrofit: techniques

Direct co-firing with common injection

Indirect co-firing with partial gasification

hot syngas 850°C

CFB gasifier

Retrofit Awirs4 power plant

- 350,000 mt/year wood pellets
- 80 MWe
The pathways to biomass retrofit

**Biomass sustainability**
- Certification procedure
- Traceability
- Audit of biomass suppliers
- CO₂ balance of supply chain

**Pellets handling**
- Capacity up to 200 t/h
- New cleaning design
- ATEX conveyors

**Combustion**
- Improvement of fuel/air settings
- Controlled flame length
- New air balancing
- Low NOx Burners
- CFD analysis

**Milling**
- From 5 up to 150 t/h
- Wearing under study
- ATEX area 20

**Safety and IC**
- Zonage EN 79810-2
- Safety assessments
- ATEX 137
- ATEX 95

**Flue gas cleaning and measurements**
Emissions of SOₓ, NOₓ, dust, CO₂

**Electrabel**
### GDF SUEZ case studies

#### Capacity of (co-)firing biomass (BE+NL+POL)

<table>
<thead>
<tr>
<th>SITE + % biomass</th>
<th>UNIT</th>
<th>Hardcoal MWe</th>
<th>Biomass products</th>
<th>CAPACITY ton ar/year</th>
<th>Green power MWe</th>
<th>DATE COD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium RUIEN 18%</td>
<td>UNIT 3</td>
<td>130</td>
<td>Olive cake</td>
<td>20.000</td>
<td>7</td>
<td>2003</td>
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<tr>
<td></td>
<td>UNIT 4</td>
<td>122</td>
<td>Wood dust</td>
<td>35.000</td>
<td>10</td>
<td>2002</td>
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<td></td>
<td>UNIT 5</td>
<td>190</td>
<td>Wood chips gas, Wood milling</td>
<td>120.000, 150.000</td>
<td>20, 30</td>
<td>2003, 2007</td>
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<tr>
<td>Belgium MaxGreen RODENHUIZE 60% --&gt; 100%</td>
<td>UNIT 4</td>
<td>240</td>
<td>Wood pellets</td>
<td>850.000</td>
<td>190</td>
<td>2011</td>
</tr>
<tr>
<td>Belgium AWIRS 100%</td>
<td>UNIT 4</td>
<td>130</td>
<td>Wood pellets</td>
<td>400.000</td>
<td>80</td>
<td>2005</td>
</tr>
<tr>
<td>Netherlands GELDERLAND 7% --&gt; 20%</td>
<td>UNIT 13</td>
<td>635</td>
<td>Wood pellets</td>
<td>500.000</td>
<td>138</td>
<td>2010</td>
</tr>
<tr>
<td>Poland POLANIEC 10% --&gt; 15%</td>
<td>7 UNITS</td>
<td>1575</td>
<td>Wood chips 2012, Agri biomass 2012</td>
<td>150.000, 300.000</td>
<td>50, 100</td>
<td>2009, 2009</td>
</tr>
<tr>
<td></td>
<td>Green Unit</td>
<td>190</td>
<td>80% wood-20% agri</td>
<td>1.100.000</td>
<td>190</td>
<td>2012</td>
</tr>
<tr>
<td>EUROPE (BE + NL + POL) 25%</td>
<td>3212</td>
<td>Biomass</td>
<td>3.625.000</td>
<td>815</td>
<td>2012</td>
<td></td>
</tr>
</tbody>
</table>

| Essentialy imported | 1.770.000 | 601 |
| Essentialy local origin | 1.855.000 | 214 |
GDF SUEZ case studies: full biomass conversion

RODEHUIZE UNIT4
1979: 262 MWe
Fuels: hardcoal, blast furnace gas, fuel-oil A
2005: 55 MWe = 30% wood pellets
2008: 110 MWe = 60%
2011: 200 MWe = 100%

Les AWIRS UNIT4
1967: 125 MWe oil+gas
1982: 125 MWe coal
2005: 80 MWe biomass
GDF SUEZ case studies: Max Green

**LUCHTFOTO**
INSTALLED POWER
200 MWe

FUEL
WOOD, PELLETS

CONSUMPTION PER YEAR
850,000 TON

AVOIED COAL
550,000 TON

AVOIED CO2 PER YEAR
1,400,000 TON

GREEN ELECTRICITY PER YEAR
1,400,000 MWh equivalent to
320,000 families

INVESTMENT
125 M€

OPERATION TIME
2011-2021

EMPLOYEMENT
500 man.years
Max Green: very low emissions

- 560 MW$_{th}$ for biomass or BFG up to 200 MW$_{th}$ NG
- Tight limits on NOx emission
  - Max 60 mg/Nm$^3$ dry @11%O$_2$
  - Need for secondary measures: SCR-DeNOx

**WORLD PREMIERE OF 100% WOOD IN LARGE SCALE PF BOILER WITH HIGH DUST SCR**

- Low dust ELV
  - Max 10 mg/Nm$^3$ dry @11%O$_2$
  - No additive injection
- NH$_3$
  - Max 7 ppmv NH$_3$ (BREF)
The SCR at Rodenhuize

- High-dust SCR position
- 3+1 catalyst layers
- Two main operation modes:
  - 100% wood
  - 100% blast furnace gas
- 24.5%wt NH$_4$OH use

Main design characteristics (wood)
- Flue gas flow = 860,000 Nm$^3$/hr (wet, 6%O$_2$)
- Inlet NO$_x$ = 400 mg/Nm$^3$ (dry, 6%O$_2$)
- Outlet NO$_x$ = 90 mg/Nm$^3$ (dry, 6%O$_2$)
- NH$_3$ slip = 7 ppmv
- Dust = ~2 g/Nm$^3$ (dry, 6%O$_2$)
Rodenhuize SCR plant

ABB LS25: NH₃

ABB LIMAS + Magnos: NO, NO₂ en O₂

ABB LS25: NH₃

ABB LIMAS + Magnos: NO, NO₂ en O₂

Multiplexing
Max Green: scope of works
Max Green: scope of works

Unit 4

Condenser revamping
Auxiliary circuits modifications
3rd biomass milling installation
# The different approaches to reduce NOx

## Primary measures
- Low NOx burners
- Air and/or fuel staging
- Boiler derating
- Fuel choice

## Secondary measures
- SNCR
- Hybrid SNCR/SCR
- SCR

## Main drivers
- Advanced CFD knowledge for biomass
- Combustion experience with biomass
- Slagging and corrosion
- Availability & sustainability

## Drawbacks
- (Too) high NH$_3$ slip with PF boiler
- Feasibility in-duct SCR rarely attractive
- Need for CAPEX/OPEX optimization
The challenges of SCR technology with biomass

**SCR-DeNOx for biomass power plants - evolution**

<table>
<thead>
<tr>
<th>Scale</th>
<th>PF Co-firing</th>
<th>Grate 100% wood</th>
<th>Small scale CFB 100% biomass</th>
<th>PF 100% wood and peat</th>
<th>PF 100% wood World Premiere</th>
<th>Large scale CFB 100% biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;120 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>&lt;25 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>&lt;100 MW&lt;sub&gt;i&lt;/sub&gt;</td>
<td>&gt;100 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>Laborelec pilot plant</td>
<td>&gt;200 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>&gt;180 MW&lt;sub&gt;e&lt;/sub&gt;</td>
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</table>

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Coal &amp; biomass</th>
<th>100% wood</th>
<th>100% biomass</th>
<th>100% peat&amp;wood</th>
<th>100% wood</th>
<th>100% wood</th>
<th>100% wood and agri biomass</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Boiler type</th>
<th>PF Grate boiler</th>
<th>CFB</th>
<th>PF</th>
<th>PF</th>
<th>PF</th>
<th>CFB</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>DeNOx type</th>
<th>SCR high dust</th>
<th>SNCR SCR low dust</th>
<th>SNCR SCR low dust</th>
<th>SNCR SCR high dust</th>
<th>SCR high dust</th>
<th>SCR high dust</th>
<th>SNCR SCR low dust</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Belgium Netherlands</th>
<th>USA</th>
<th>Austria Netherlands</th>
<th>Sweden</th>
<th>Belgium</th>
<th>Belgium</th>
<th>Poland</th>
</tr>
</thead>
</table>

| GDF SUEZ | Yes | Yes | No | No | Yes | Yes | Yes |


The challenges of SCR technology with biomass

REX from GDF SUEZ power plants and SCR pilot plant

- Deactivation rates with 100% wood firing
- Deactivation mechanisms
- Different types of NH$_3$ slip constraints
- New type of catalyst formulation
- Influence of the position of the SCR in the FGC chain
- Influence of boiler type
- Influence of fuel and operating conditions
- Potential of additives
- Catalyst regeneration versus catalyst washing
The challenges of SCR with 100% wood

→ Desactivation strongly function of design and operating parameters

→ For a given boiler (even with PF), room for significant CAPEX/OPEX savings
CONCLUSIONS

- The keys of a wood retrofit project
  - Fuel sourcing and market demand
  - Sustainability, social, ethics aspects
  - Green support mechanisms
  - Safety and ATEX
  - Retrofit technologies
  - Engineering and project management

- Dealing with stringent ELV’s
  - NOx is the most critical
  - Several options for NOx emissions
    - Boiler and fuel dependent
    - SNCR not sufficient for PF boiler
    - Room for CAPEX/OPEX optimization with SCR
  - ESP upgrade is sufficient for dust emissions
DON’T HESITATE TO CONTACT US!

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ANY QUESTIONS?
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- Independent advice based on certified laboratory and field analyses all over the world
- More than 50 years of experience