MILENA-OLGA technology
Development of Biomass and Waste Gasification towards Green Chemicals

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Dahlman Renewable Technology BV ("DRT") develops gasification and syngas purification technologies in cooperation with ECN since 2001.

DRT was part of Royal Dahlman, a technology company, established in 1886 serving the oil & gas and power market worldwide.

Synova acquired DRT from Royal Dahlman in 2017.
DRTs technology scope
**MILENA: robust, efficient, fuel flexible**

- **Wood**
- **Pomace**
- **Waste wood**
- **Soya stalk**
- **Waste (RDF)**

- **Chip size:** 3”, max. 4” (l × w × h)
- **Moisture:** 20% - 30%, max. 35%
- **Volatile:** preferably > 55%
- **Alkali:** preferably < 0.4%

Fuel test are made possible by contributions of the Netherlands Enterprise Agency.
Tar removal is key in the flexibility, efficiency and success of any advanced gasification technology.
Tar removal: the most important step

- OLGA is able to handle very high tar loads, up to 50 g/Nm$^3$
- OLGA does not convert the tars, hence does also not convert valuable hydrocarbons such as methane, ethylene and BTX
- OLGA has low pressure drop and only consumes some electricity for pumps and tracing (~1% parasitic load on gross power production)
- OLGA captures tars with high efficiencies >99%, resulting in a dew point < 15°C (59°F)
Tar removal: the most important step

OLGA, an acronym for “Oil - Gas”, is a two loop oil scrubbing system

1. Removing heavy tars and dust in the 1st loop as a liquid slurry
2. Removing light tars such as naphthalene and phenol in the 2nd loop dissolved in air or steam

Both tar streams are circulated back to the gasifier, making OLGA a tar waste free system.
MILENA-OLGA Experience

Lab scale
The Netherlands
0.005 MW\textsubscript{th}
CFB, BFB, MILENA

Industrial Pilot
The Netherlands
0.5 / 0.8 MW\textsubscript{th}
CFB / MILENA

Demonstration
France
4 MW\textsubscript{th}
Special FBU

Commercial
Portugal
4 MW\textsubscript{th}
CFB

Commercial
India
5 MW\textsubscript{th}
MILENA
What is MILENA?

• An indirect gasifier that separates the combustion reactions and pyrolysis reactions in two different reactors, integrated in one refractory lined vessel.

• Which makes it possible to optimize ash burn out, hence, reach 100% carbon to gas ratio and

• Prevents dilution by N\textsubscript{2} from combustion air and CO\textsubscript{2} and H\textsubscript{2}O from the combustion process.

3 to 4 times more heating value than direct air blown gasifiers, 60% more than oxygen/steam blown gasifiers.
OLGA enables MILENA to excel

- With tar levels > 40 g/Nm³, OLGA and thermal cracking are the only reasonable alternatives.
- The ability to cope with high tar concentrations gives operational freedom to MILENA.
- OLGA removes tars and dust, it does not change the product gas composition.

![Graph showing comparison of tar removal and cold gas efficiency for different technologies.](image_url)
MILENA-OLGA product gas composition

- Sand bed material (not catalytically active)
- Wood 2% ash, 25% moisture 18.8 MJ/kg (daf)
- RDF 10% ash, 30% moisture, 27.1 MJ/kg (daf)
- Product gas cooled to ~35°C (7% moisture)

Results in
- Wood: LHV 17.0 MJ/Nm³ (432 Btu/scf)
- RDF: LHV 24.4 MJ/Nm³ (620 Btu/scf)

Without any primary measures or gas conditioning

<table>
<thead>
<tr>
<th>MILENA-OLGA clean product gas</th>
<th></th>
<th>Waste Wood</th>
<th>RDF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product Gas Composition</strong></td>
<td>Unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>vol%</td>
<td>31.8</td>
<td>19.8</td>
</tr>
<tr>
<td>H2</td>
<td>vol%</td>
<td>19.2</td>
<td>14.7</td>
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<tr>
<td>CO2</td>
<td>vol%</td>
<td>13.8</td>
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<tr>
<td>O2</td>
<td>vol%</td>
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<td>0.0</td>
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<tr>
<td>H2O</td>
<td>vol%</td>
<td>7.0</td>
<td>7.0</td>
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<tr>
<td>CH4</td>
<td>vol%</td>
<td>13.3</td>
<td>16.4</td>
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<tr>
<td>N2</td>
<td>vol%</td>
<td>8.5</td>
<td>10.2</td>
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<tr>
<td>Ar</td>
<td>vol%</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>C2H2</td>
<td>vol%</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>C2H4</td>
<td>vol%</td>
<td>4.4</td>
<td>12.0</td>
</tr>
<tr>
<td>C2H6</td>
<td>vol%</td>
<td>0.3</td>
<td>1.2</td>
</tr>
<tr>
<td>C3Hy (modeled as C3H6)</td>
<td>vol%</td>
<td>0.0</td>
<td>1.9</td>
</tr>
<tr>
<td>C4Hy (modeled as C4H8)</td>
<td>vol%</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>C5Hy (modeled as C5H10)</td>
<td>vol%</td>
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<td>0.0</td>
</tr>
<tr>
<td>C6H6 (benzene)</td>
<td>vol%</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>C7H8 (toluene)</td>
<td>vol%</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>vol%</td>
<td>99.9</td>
<td>98.9</td>
</tr>
<tr>
<td><strong>Wobbe (LHV)</strong></td>
<td>MJ/Nm³</td>
<td>17.0</td>
<td>24.4</td>
</tr>
<tr>
<td><strong>Wobbe (LHV)</strong></td>
<td>Btu/scf</td>
<td>432</td>
<td>620</td>
</tr>
</tbody>
</table>
MILENA gives energy density

- An air blown gasifier, no need for an air separation unit
- Producing a gas with a Wobbe (LHV) of 20 MJ/Nm³, 500 Btu/scf
- Makes the connection to a downstream gas turbine easily possible
MILENA-OLGA power from 30MW Thai waste

- 6720 kg/hr RDF, 160 tpd
- 8 MW electricity sales
- The efficiency (27%) is lower because of investment savings (less heat recuperation) and the parasitic load of the zero water discharge system.
- This plant does not produce waste water and minimizes the fresh water consumption.
- Site selection, FEED, safety studies, permitting completed. Plant ready for construction, which will start in 2018 when the PPA is confirmed.
MILENA-OLGA product gas energy

**Waste Wood**
- Syngas CO+H2: 30%
- Methane: 24%
- C2 (ethylene): 15%
- C3/C4 olefins: 0%
- BTX: 8%
- Heat Loss: 4%
- Loss inorganics removal: 2%
- Recoverable Heat: 17%

**RDF**
- Syngas CO+H2: 14%
- Methane: 20%
- C2 (ethylene): 28%
- C3/C4 olefins: 9%
- BTX: 6%
- Loss inorganics removal: 2%
- Recoverable Heat: 17%

Fuel LHV (wood / RDF) = 100
Production of chemicals

- Easy BTX co-production by an OLGA add-on, > 95% Separation Efficiency
- 8% of the RDF fuel (10% of the product gas energy)

Production of BTX-water mixture:

- Syngas CO+H2 30%
- C2 (ethylene) 15%
- Methane 24%

Waste Wood
Ambigo green gas project NL

- 4 MW MILENA-OLGA on waste wood
- 24% of the wood, 30% of the PG, is CH4 prior to methanation

Construction starts 2018
MILENA-OLGA as basis for fuels and chemicals

160 tpd RDF,
30 MW
2500 MM Btu/day

19.5 MW LNG
1600 MM Btu/day

15.5 MW FT Diesel
1340 MM Btu/day

“OR”

21 MW Bio SNG,
1720 MM Btu/day
MILENA-OLGA as basis for fuels and chemicals

160 tpd RDF, 30 MW, 2500 MM Btu/day

11.5 MW FT Diesel, 940 MM Btu/day

2.85 MW BTX, 230 MM Btu/day

“AND” (co-production)

8 MW LNG, 655 MM Btu/day
Thank you

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