Innovations in Biogas production
in Industrial and Municipal Sludge Digesters

Workshop Biogas April 6th 2017
Part I: Colsen

I.1. About Colsen
I.2. Colsen partners
I.3. Services and technologies
I.4. Key Sectors
I.5. Key Products

Part II: Colsen products

II.1. Digestion
II.2. Biogas
I.1. About Colsen

Custom solutions

R&D

Innovation

Family company

Flexibility

28 years

Open communication

Wastewater treatment

Biogas production

Water, Energy & Environment

Nutrient recovery

International

Water, energy & environment

28 years
### 1.2. Colsen partners

<table>
<thead>
<tr>
<th>Partner</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>Colsen Group (Headquarters)</td>
<td>Nederland</td>
</tr>
<tr>
<td>Colsen b.v.b.a.</td>
<td>Belgium</td>
</tr>
<tr>
<td>Ahidra Colsen Technologies</td>
<td>Spain</td>
</tr>
<tr>
<td>Aquest Colsen</td>
<td>South Africa</td>
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<tr>
<td>HydroItalia</td>
<td>Colsen SRL</td>
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<tr>
<td>Clear Industry Co. Ltd.</td>
<td>China</td>
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<tr>
<td>IBS</td>
<td>Argentina</td>
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<td>Aqualimpia</td>
<td>El Salvador</td>
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<tr>
<td>Bioril</td>
<td>Chili</td>
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<tr>
<td>AQIP SAS</td>
<td>Colombia</td>
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<tr>
<td>Grupo GPHN</td>
<td>Mexico</td>
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<tr>
<td>Grupo MEGASAGERSA</td>
<td>Peru</td>
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<tr>
<td>Hidrotec</td>
<td>Republica Dominicana</td>
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<td>LATCONGROUP CIA LTDA</td>
<td>Ecuador</td>
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<tr>
<td>PROCKNOR ENGENHARIA LTDA</td>
<td>Brazil</td>
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<tr>
<td>Grupo GRATT</td>
<td>Brazil</td>
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1.3. Services & technologies

Solutions for...

- Organic waste treatment
- Nutrient recovery
- Biogas treatment
- (Waste)water treatment

Technologies for...

- Municipal wastewater treatment plant
- Industrial wastewater treatment plant
- Agricultural biogas plants
- Industrial biogas plants
I.4. Key sectors

Colsen builds TAILOR-MADE & TURN-KEY plants in following key sectors

- Food & beverages
  - Potato
  - Slaughterhouses
  - Dairy
  - etc.
- Municipalities
- Agricultural sector
- Pulp & paper
- Pharmaceutics
- Petrochemical

Vion, Boxtel (NL)
I.5. Key products

Wastewater
- UASB

Digestion
- DIGESTER
- DIGESTMIX®
- POUL-AR®

Biogas line
- NAS® anammox
- RO-recycle®

Nutrient recovery
- BIDOX®
- AMFER®
- ANPHOS®

Products with a direct link to biogas
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Part II: Colsen products

II.1. Digestion
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II.1. Digestion
II.1.1. Digester

Process applications:

- Industrial organic waste products
- Agricultural energy products: manure; maize, etc.
- WWTP sludge: primary sludge; activated sludge, etc.
- Combined various waste streams

Process principle:
II.1.1.a. Digester: thermophilic

Thermophilic vs. mesophilic

- Faster biomass metabolism
- Smaller digester
- More residue converted
- Enhanced conversion of fibrous material
- Lower degree of carbon residuals
Practical experience with thermophilic digestion

Pilot research WWTP Bath 2012-2017:
(Full-scale) pilot research at WWTP Bath 2012-2017:

✓ Pilot research at small scale and large scale pilot (18 m³);

✓ Adjusting one full-scale (mesophilic) digester for thermophilic operation;

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Compared with mesophillic digestion</th>
</tr>
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<tbody>
<tr>
<td>ODM conversion</td>
<td>+ 12.7 %</td>
</tr>
<tr>
<td>Methane production</td>
<td>+ 17.9 %</td>
</tr>
</tbody>
</table>

Source: De Vrieze, J., et al. (2016)
✓ EcoFuels (2007): 3 x 3400 m³
✓ Pizzolli (2015): 1 x 1800 m³
✓ RWZI Den Bosch (2017): 2 x 4000 m³
Our approach to thermophilic digestion in practice

Thermophilic digestion process is stable when certain conditions are taken into account:

✓ Temperature fluctuations influence efficiency
  ✓ (+/- 0,5 ° C per day)

✓ Analysis of heat balance
Isolation and heat exchange:

- Den Bosch: before and after
- Heat loss reduced from 450 kW to 45 kW per tank
Our approach to thermophilic digestion in practice

DigestMix:
II.1.3. Poul-AR®

**Poul-AR®: General system**
- Step 1: Ammonification with enzymes
- Step 2: De-ammonification with addition lime
- Up to 90% NH4-N removal over the complete system
- Minimal COD loss
- Formation of N-fertilizer: e.g. 52% NH4NO3
- NPK for 52% NH4NO3 is 18-0-0

**Poul-AR®: Effluent potential**
- High temperature effluent accessible for high temperature digestion processes
- No-toxic N concentration for mesophilic and thermophilic digestion processes
- High biogas/energy potential
- 100 Nm³ CH₄ per ton manure
II.1.3.b. Poul-AR® innovation route

2012: Project idea and literature research
2013: Preliminary labscale test of individual processes
2014: Successfull European H2020 subsidy:
   ➢ Labscale testing
   ➢ Market research
2015: Labscale optimization
2016: Pilot scale verification
2017: Demonstration of Poul-AR® at full scale TKI hernieuwbare energie
2018: Exploitation full scale demonstration plant
II.2. Biogas
II.2.1.a. BIDOX®

**BIDOX®** = Biological biogas Desulphurization by Oxidation

\[ \text{H}_2\text{S} + 2\text{O}_2 \rightarrow \text{SO}_4^{2-} + 2\text{H}^+ \]

**Process conditions**
- Air supply: oxygen
- Nutrients supply
- Temperature: 35-37°C
- Fresh water supply
- Packed media

**Process figures**
- \( \text{H}_2\text{S} \) loading capacity: \( \sim 0.5 - 50.0 \text{ kg h}^{-1} \)
- Biogas flow range: \( \sim 25 - 3,000 \text{ Nm}^3 \text{ h}^{-1} \)
- \( \text{H}_2\text{S} \) outlet conc.: \( < 20 - 200 \text{ ppm} \)
- Power consumption: \( \sim 0.2 \text{ kWh kg}^{-1} \text{ H}_2\text{S} \) removal
- Operational cost: \( \sim €0.2 \text{ kg}^{-1} \text{ H}_2\text{S} \) removal

www.colsen.nl
II.2.1.b. BIDOX® advantages

Process advantages

- Robust system quality
- High efficiency
- No chemical requirements
- Low running costs
- No cleaning intervals and process downtime
- No solid disposal
- No clogging ❯ Unique BIDOX® advantage!

At low PH ≤ 1.5 – 2

- Almost all sulphur is converted into \( \text{SO}_4^{2-} \)
- Only a minor part formed as elemental sulphur

❯ Removed as suspended solid with the effluent!

BIDOX® - 2004

After 7 years of non-stop operation, BIDOX® was opened for inspection.

The filling material contained some sulphur at the outside borders and no sulphur inside.