Utvikling av teknologi for bærekraftig utnyttelse av energi og næringsstoffer

Privat industri og offentlig forskning i samarbeid

Hans Rasmus Holte
Technical Manager Biorenewables
CAMBI’S BUSINESS AREAS

**Biosolids:**
Plants for enhanced biogas production from municipal & industrial sludge

**Biowaste:**
Plants for biogas and biofertilizer from source-separated organic waste

**Biorenewables:**
- Biogas production from organic residues
- Ligno-cellulosic biomass pre-treatment for bio-ethanol & biogas

**Operations:**
Cambi Operations provides support and operation services to maximize plant performance
<table>
<thead>
<tr>
<th>Customer/project</th>
<th>Location</th>
<th>Design capacity (TDS/year)</th>
<th>THP reactors</th>
<th>TYPE</th>
<th>Completed</th>
<th>no. of plants</th>
<th>Application</th>
<th>Product end-use</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIAS (1)</td>
<td>Hamar, Norway</td>
<td>3,600 tonnes</td>
<td>1</td>
<td>WWTP</td>
<td>1996</td>
<td>1</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Thames Water (2)</td>
<td>Chertsey, UK</td>
<td>9,600 tonnes</td>
<td>2</td>
<td>WWTP</td>
<td>1999</td>
<td>2</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Borregaard Industries</td>
<td>Sarspborg, Norway</td>
<td>4,000 tonnes</td>
<td>1</td>
<td>PAPER</td>
<td>2000</td>
<td>3</td>
<td>W</td>
<td>I</td>
</tr>
<tr>
<td>The Municipality of Næstved*</td>
<td>Næstved, Denmark</td>
<td>1,600 tonnes</td>
<td>1</td>
<td>WWTP*</td>
<td>2000</td>
<td>4</td>
<td>W</td>
<td>A</td>
</tr>
<tr>
<td>Nigg Bay</td>
<td>Aberdeen, UK</td>
<td>16,500 tonnes</td>
<td>4</td>
<td>WWTP</td>
<td>2001</td>
<td>5</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>&quot;Mjøsanlegget&quot;, Biowaste Plant</td>
<td>Lillehammer, Norway</td>
<td>4,600 tonnes</td>
<td>2</td>
<td>OFMSW</td>
<td>2001</td>
<td>6</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Ringsend Sewage Treatment Works</td>
<td>Dublin, Ireland</td>
<td>36,000 tonnes</td>
<td>8</td>
<td>WWTP</td>
<td>2002</td>
<td>7</td>
<td>F</td>
<td>D, A</td>
</tr>
<tr>
<td>The Municipality of Fredericia</td>
<td>Fredericia, Denmark</td>
<td>8,000 tonnes</td>
<td>2</td>
<td>WWTP</td>
<td>2002</td>
<td>8</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Kobelco Eco-Solutions</td>
<td>Niigata, Japan</td>
<td>1,200 tonnes</td>
<td>1</td>
<td>WWTP</td>
<td>2002</td>
<td>9</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Spolka Wodna Kapusciska</td>
<td>Bydgoszcz, Poland</td>
<td>8,000 tonnes</td>
<td>2</td>
<td>WWTP</td>
<td>2005</td>
<td>10</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Thames Water</td>
<td>Chertsey, UK</td>
<td>Included in (2)</td>
<td>0</td>
<td>Operations</td>
<td>2005 - 2012</td>
<td>Part of 2</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>HIAS, additional digester</td>
<td>Hamar, Norway</td>
<td>Included in (1)</td>
<td>0</td>
<td>New digester</td>
<td>2005</td>
<td>Expanding 1</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Oxley Creek</td>
<td>Brisbane, Australia</td>
<td>12,900 tonnes</td>
<td>3</td>
<td>WWTP</td>
<td>2007</td>
<td>11</td>
<td>W</td>
<td>A</td>
</tr>
<tr>
<td>Bruxelles Nord</td>
<td>Bruxelles, Belgium</td>
<td>20,000 tonnes</td>
<td>5</td>
<td>WWTP</td>
<td>2007</td>
<td>12</td>
<td>W</td>
<td>O</td>
</tr>
<tr>
<td>HIAS- Expansion</td>
<td>Hamar, Norway</td>
<td>3,600 tonnes</td>
<td>1</td>
<td>WWTP</td>
<td>2007</td>
<td>Expanding 1</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Cotton Valley (Anglian Water)</td>
<td>Milton Keynes, UK</td>
<td>20,000 tonnes</td>
<td>4</td>
<td>WWTP</td>
<td>2008</td>
<td>13</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Ecopro, multi-waste** plant</td>
<td>Verdal, Norway</td>
<td>8,000 tonnes</td>
<td>2</td>
<td>OFMSW***</td>
<td>2008</td>
<td>14</td>
<td>B + F</td>
<td>A</td>
</tr>
<tr>
<td>Whittingham WWTW (Anglian Water)</td>
<td>Norwich, UK</td>
<td>19,000 tonnes</td>
<td>4</td>
<td>WWTP</td>
<td>2008</td>
<td>15</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Biovakka Oy</td>
<td>Abo/Turku, Finland</td>
<td>14,000 tonnes</td>
<td>3</td>
<td>WWTP</td>
<td>2008</td>
<td>16</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Nigg Bay, upgrade</td>
<td>Aberdeen, UK</td>
<td>4,000 tonnes</td>
<td>0</td>
<td>WWTP</td>
<td>2009</td>
<td>Expanding 5</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Bran Sands (Aker-Kværner/NWL)</td>
<td>Tees Valley, UK</td>
<td>37,000 tonnes</td>
<td>8</td>
<td>WWTP</td>
<td>2009</td>
<td>17</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Amperverband, Cambi THP-C*</td>
<td>Geisenbullach, Germany</td>
<td>2,000 tonnes</td>
<td>1</td>
<td>WWTP</td>
<td>2009</td>
<td>18</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>Ringsend STW (New THP line)</td>
<td>Dublin, Ireland</td>
<td>20,000 tonnes</td>
<td>4</td>
<td>WWTP</td>
<td>2010</td>
<td>Expanding 7</td>
<td>F</td>
<td>D, A</td>
</tr>
<tr>
<td>Cardiff, Welsh Water (Imtech)</td>
<td>Wales, UK</td>
<td>30,000 tonnes</td>
<td>6</td>
<td>WWTP</td>
<td>2010</td>
<td>19</td>
<td>W</td>
<td>A</td>
</tr>
<tr>
<td>Afan, Welsh Water (Imtech)</td>
<td>Wales, UK</td>
<td>20,000 tonnes</td>
<td>4</td>
<td>WWTP</td>
<td>2010</td>
<td>20</td>
<td>F</td>
<td>A</td>
</tr>
</tbody>
</table>
# CAMBI PLANTS (in design/construction)

<table>
<thead>
<tr>
<th>Ordered Plants / Under design/construction</th>
<th>London UK</th>
<th>40,000 tonnes</th>
<th>8</th>
<th>WWTP 2011</th>
<th>21</th>
<th>F</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverside, Thames W (Interserve)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vilniaus Vandenyts/ Vilnius Water Co.</td>
<td>Vilnius Lithuania</td>
<td>23,000 tonnes</td>
<td>5</td>
<td>WWTP 2011</td>
<td>22</td>
<td>F</td>
<td>D, A</td>
</tr>
<tr>
<td>Dawyhulme, UU (B&amp;V)</td>
<td>Manchester UK</td>
<td>91,000 tonnes</td>
<td>20</td>
<td>WWTP 2011</td>
<td>23</td>
<td>F</td>
<td>A, I</td>
</tr>
<tr>
<td>Lindum, Cambi Compact</td>
<td>Drammen Norway</td>
<td>6,000 tonnes</td>
<td>2</td>
<td>WWTP 2011</td>
<td>24</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>Mapocho WWTP (Degremont)*</td>
<td>Santiago Chile</td>
<td>25,000 tonnes</td>
<td>6</td>
<td>WWTP 2011</td>
<td>25</td>
<td>H</td>
<td>A</td>
</tr>
<tr>
<td>Oslo EGE</td>
<td>Oslo Norway</td>
<td>15,000 tonnes</td>
<td>2</td>
<td>OFMSW*** 2012</td>
<td>26</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Howdon (Imtech/NWL)</td>
<td>Newcastle UK</td>
<td>40,000 tonnes</td>
<td>8</td>
<td>WWTP 2012</td>
<td>27</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>DC Water*</td>
<td>Washington DC USA</td>
<td>130,000 tonnes</td>
<td>24</td>
<td>WWTP 2011</td>
<td>26</td>
<td>F</td>
<td>A</td>
</tr>
</tbody>
</table>

**TDS = Total dry solids (1000 kg = 1 tonne)**

**Total:** 673,600 tonnes

<table>
<thead>
<tr>
<th>In operations:</th>
<th>303,600 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under design/construction:</td>
<td>370,000 tonnes</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>673,600 tonnes</td>
</tr>
</tbody>
</table>

* Sole-Source Component – DC Water developed a “determination and findings” concluding that Cambi is the sole-source provider of the THP.

On July 2, 2009, the DC WASA General Manager issued a Determination and Findings to allow the sole source procurement of the Cambi THP.

### Applications:
- **H:** Cambi Hybrid (WAS only TH mixed with untreated P), not Class A
- **W:** WAS, biological sludge, only (usualy extende aeration)
- **F:** Full Cambi, TH of both P and WAS sludge, Class A
- **B:** Biowaste
- **O:** Wet-air oxidation

### Product end-use:
- **A:** Use of end product in agriculture
- **D:** Drying of end-product
- **I:** Incineration of end-product
CAMBI BIOWASTE PROCESS

Ecopro, Verdal, Cambi multi-fuel plant, Turn key project, 2008
SUSTAINABILITY OF BIOFUELS

Compressed Bio Gas cheap and twice the potential of other biofuel

Why is Sweden the only one to understand this?

Source: http://www.gasbilen.se/Att-tanka-pa-milion/Fordonsgas-i-siffror/GasbilarUtveckling
INDEPENDENT R&D, IMPORTANT MEASURE TO DOCUMENT PROCESSES AND EFFICIENCIES

Independent R&D important for both plant owners and authorities to compare technologies and methods.

Independent R&D has proven Cambi Thermal Hydrolysis to be Best Available Technology (BAT)

Cambi has som strategi å etablere et nettverk av dyktige universits miljøer, Denne strategien styrker Cambi’s FOU kapasitet, og evne til videre vekst som en verdensledende teknologi leverandør

Eksempel på universitets samarbeid:

- UMB Univ. Norway
- PFI, Norway (LignoRef)
- SLU, Sweden (MicroDrive)
- Univ. of Valladolid, Spain
- Universität für Bodenkultur (BOKU), Wien
- Braunschweig Univ., Germany
- Virginia Tech, USA
- Norwich, UK
- Tohuko Univ., Japan
- Tsinghua and Tianjin Univ., China
- Pontifical Catholic Univ. of Valparaiso, Chile
OPTIMIZING BIOGAS YIELD
EFFECT OF PRETREATMENT WITH CAMBI THP

Example of results from University projects:

Aspen

![Graph showing the effect of pretreatment on biogas yield](image)

**Stor utfordring i å få frem entydige resultater som grunnlag for store investeringer**
(tollkning, repeterbarhet, analysemetoder)
GROWTH YIELD TESTS WITH CAMBI CAKE

Attractive bio-fertilizer due to:
• pathogen-free & nutritious
• No odour (smells like soil)
• Typical 30% DS content

Effect of N and Cambi cake on yield of spring barley grain (85% DMI)

Growth yield Scotland: Aberdeen 2002

Growth yield Norway, Egil Ekeberg, 1998
RESULTS FROM CARBON FOOTPRINT STUDIES
Davyhulme in Manchester, United Utilities, UK

Cumulative carbon cost and emissions for three alternative methods

“… [The] thermal hydrolysis pretreatment system at … Davyhulme … will reduce [United Utilities’] carbon footprint by 8% - the equivalent of removing 270,000 cars off the road for 30 years.”, March-April 2009, Worldwater

Figure 12: Cumulative carbon cost (full lines primary y axis) and cumulative carbon emissions (dashed lines secondary y axis) for the three options studied

SLUDGE TREATMENT CENTER
DAVYHULME, UNITED UTILITIES, UK

- 91,000 metric tonnes DS/year
- Doubling of capacity of existing 8 x 7,400 m³ digesters
- 4x5 reactor Cambi THP + cooler system
- 10 MW electricity + THP steam
- Pasteurized product
- Reduced energy for drying and incineration

- Carbon emissions reduced by 32,000t CO2 equivalents/year
- High performance digestion
- High dry solids final product
- Maximized VS reduction
SIGNIFICANT O&M SAVINGS WITH CAMBI THP

VirginiaTech (University) evaluation of biosolids treatment methods, important basis for technology selection at DCWASA, Washington DC.

Figure 1-O&M Cost Comparison* of Digestion Project (Biosolids Program) vs. Lime Stabilization (continued and expanded) with 3% annual inflation.

THE OSLO, EGE BIOGAS PLANT, NORWAY

Cambi biowaste process - Cambi turn-key supplier -

Capacity: 50 000 t/y
- Upgraded biogas for Oslo City center busses
- Refined Biofertilizer
- Integrated heat & process water recovery
- Advanced reject water treatment.

Green field project at the Esvald landfill site
(Click on picture for animation)

EGE Biogas, Esvald 14.10.2011

Cambi - recycling energy