Second Generation Bio-fuels in a Cold Climate
- The Experience of Aalborg

Gustav Friis – City of Aalborg
Where is Aalborg?
Aalborg and CIVITAS ARCHIMEDES

**Facts**

- Total population: 200,000 inhabitants
- City population: 120,000 inhabitants
- Municipality area: 1,144 km²
- Road network: 2,000 km
Demonstration – 50 buses
Bio-diesel demonstration in buses

- Reducing CO2 emissions from buses with 140 t of CO2 per year
- Reduce the use of fossil fuels
- Testing new technologies in public transport and postal service
**Bio-diesel**

- Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters.

- Biodiesel is typically made by chemically reacting lipids (e.g. vegetable oil, animal fat (tallow)) with an alcohol.
Bio-diesel in Aalborg

- Biodiesel consists of fatty acid methyl esters (FAME) created as the result of a reaction between an alcohol and oils/fats of vegetable or animal origin.

- Methanol (wood alcohol) is usually the alcohol of choice, but ethanol may also be used.

- Daka Biodiesel is primarily being produced using refined animal fat extracted from **slaughterhouse by-products** and **dead animals** from primary agriculture. Other by-products in the form of used cooking oil and other oils unsuitable for food production may also be used in the production process. (source: dakabiodiesel.dk)
So Far So Good

The demonstration has begun

- 1st of October 2010 – 50 buses
Challenges

• Tendering process,
  • How to fix the extra costs
  • How to fix the responsibility

• Technical issues, bio-diesel has other properties than standard diesel
  • Fat and cool
  • Blending with oil
  • Warranties of the engines

• Fuelling facilities - mixing the right blend
  • Two strategies demonstrated
Public Transport in Aalborg

North Jutland Region

Municipalities In the Region

Tenders on public transport packages

Private Operator 1

Private Operator 2

Private Operator n

Public Transport Planning

Public Transport Operation

Clean Vehicles, Clean Fuels, Cleaner Cities – Donostia-San Sebastián – June 2011
Tendering Process

- Blend – at least 10% AFME (Animal Fat Methyl Ester)
- Base diesel to ensure the right temperature stability
- Temperature stability
- Establishment of bio-fuelling stations and delivery of biodiesel
- Maintenance and service intervals for the buses
- Guarantees and insurances
- Compensation for extra costs related to fuel and maintenance
- The use of biodiesel after the end of the ARCHIMEDES project
- Data collection, including fuel consumption and maintenance etc.
Tendering Process

Operator 1, Operator 2, Operator 3, Operator 4

Diesel
Bio

Clean Vehicles, Clean Fuels, Cleaner Cities – Donostia-San Sebastián – June 2011
Tendering Process

• The tendering of the service makes it possible to give the contractors **full responsibility** for operating the fleets as requested in the tender.
• This means that the responsibility for extra maintenance or insurances on the buses is also the responsibility of the contractors.
Properties - Clouding
# Climate in Aalborg

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average high °C (°F)</strong></td>
<td>2 (36)</td>
<td>2 (36)</td>
<td>5 (41)</td>
<td>10 (50)</td>
<td>15 (59)</td>
<td>19 (66)</td>
<td>20 (68)</td>
<td>20 (68)</td>
<td>16 (61)</td>
<td>12 (54)</td>
<td>7 (45)</td>
<td>3 (37)</td>
<td>10.9 (51.6)</td>
</tr>
<tr>
<td><strong>Daily mean °C (°F)</strong></td>
<td>0 (32)</td>
<td>0 (32)</td>
<td>2 (36)</td>
<td>6 (43)</td>
<td>11 (52)</td>
<td>14 (57)</td>
<td>16 (61)</td>
<td>16 (61)</td>
<td>12 (54)</td>
<td>9 (48)</td>
<td>4 (39)</td>
<td>1 (34)</td>
<td>7.5 (45.5)</td>
</tr>
<tr>
<td><strong>Average low °C (°F)</strong></td>
<td>-3 (27)</td>
<td>-3 (27)</td>
<td>-1 (30)</td>
<td>2 (36)</td>
<td>6 (43)</td>
<td>10 (50)</td>
<td>12 (54)</td>
<td>11 (52)</td>
<td>9 (48)</td>
<td>6 (43)</td>
<td>2 (36)</td>
<td>-1 (30)</td>
<td>4.0 (39.2)</td>
</tr>
<tr>
<td><strong>Precipitation mm (inches)</strong></td>
<td>54 (2.13)</td>
<td>35 (1.38)</td>
<td>44 (1.73)</td>
<td>38 (1.5)</td>
<td>49 (1.93)</td>
<td>54 (2.13)</td>
<td>64 (2.52)</td>
<td>67 (2.64)</td>
<td>72 (2.83)</td>
<td>76 (2.99)</td>
<td>75 (2.95)</td>
<td>62 (2.44)</td>
<td>689 (27.13)</td>
</tr>
<tr>
<td><strong>Avg. precipitation days</strong></td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>12</td>
<td>124</td>
</tr>
<tr>
<td><strong>Sunshine hours</strong></td>
<td>39</td>
<td>72</td>
<td>117</td>
<td>167</td>
<td>209</td>
<td>218</td>
<td>209</td>
<td>186</td>
<td>130</td>
<td>87</td>
<td>57</td>
<td>42</td>
<td>1,534</td>
</tr>
</tbody>
</table>

Source: DMI (Danmarks Meteorologiske Institut)
Properties – Rotten Diesel
Fuelling Stations

Implementation of 3 fuelling station

• One at Arriva
  • Indoor heated tank containing bio-diesel
  • Blending while fuelling

• One at City Trafik
  • Outdoor heated tank containing bio-diesel
  • Blending while fuelling

• One at Danish Mail (Post Danmark)
  • Outdoor tank containing the blended product
  • Blended at oil supplier and delivered in the right blend
13 mode test (ESC)

Involved Vehicles

- City-Trafik Volvo bus Euro III
- Post DK Ford Transit van Euro IV
- Arriva Scania bus Euro V

Tests performed at DTI, Aarhus.

DANISH TECHNOLOGICAL INSTITUTE

Heavy duty chassis dynamometer =>
Diesel

<table>
<thead>
<tr>
<th></th>
<th>FORD</th>
<th>VOLVO</th>
<th>SCANIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ</td>
<td>9,6</td>
<td>8,5</td>
<td>1,9 g/kWh</td>
</tr>
<tr>
<td>HC</td>
<td>0,01</td>
<td>0,04</td>
<td>0,03 g/kWh</td>
</tr>
<tr>
<td>CO</td>
<td>0,1</td>
<td>0,3</td>
<td>0,0 g/kWh</td>
</tr>
<tr>
<td>PM</td>
<td>0,15</td>
<td>0,04</td>
<td>0,06 g/kWh</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>215</td>
<td>220</td>
<td>239 g/kWh</td>
</tr>
</tbody>
</table>

Laboratory measurements to be repeated in 2012.

Emissions are expected to remain the same.

Biodiesel

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<th>SCANIA</th>
</tr>
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<tr>
<td>NOₓ</td>
<td>-</td>
<td>-</td>
<td>- g/kWh</td>
</tr>
<tr>
<td>HC</td>
<td>-</td>
<td>-</td>
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<tr>
<td>PM</td>
<td>-</td>
<td>-</td>
<td>- g/kWh</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>-</td>
<td>-</td>
<td>- g/kWh</td>
</tr>
</tbody>
</table>
PEMS test on the road

<table>
<thead>
<tr>
<th>Truck Type</th>
<th>Engine Type</th>
<th>NO [ppm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scania Omnilink 3051</td>
<td>Diesel (B0)</td>
<td>400</td>
</tr>
<tr>
<td>Scania Omnilink 4428</td>
<td>Biodiesel (B10)</td>
<td>500</td>
</tr>
<tr>
<td>Volvo B12 BLE 8482</td>
<td>Diesel (B0)</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Biodiesel (B10)</td>
<td>700</td>
</tr>
</tbody>
</table>
A Hybrid!
Thank you!

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