System perspective on biogas use for transport and electricity production.

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Starting point

- There is biogas production in Linköping municipality.
- There is not a gas grid in this area.
- How should this resource be used?
Linköping municipality
Regional energy system 1 – biogas driven buses

**Fuel**

- Biogas (97% methane) locally produced
- 32 GWh (heat content)

**Conversion**

- 65 buses driven by ICE (Internal Combustion Engines) using biogas.

**Service**

- Bus transport 5.3 million km
Linköping municipality
Regional energy system 2 – District heating with CHP

Fuel
- Waste: ≈ 1300 GWh
- Wood: ≈ 175 GWh
- Coal/Rubber: ≈ 50 GWh
- Oil: ≈ 20 GWh

In total: 1500-1700 GWh annually

Conversion
- CHP (Combined Heat and Power)
- 8 boilers and 5 turbines

Service
- Heat
- Electricity
Linköping municipality
Regional energy system 1+2 – integrated system with electric buses

Fuel
- Waste
- Wood
- Coal/Rubber
- Oil
- Biogas

Conversion
- CCGT (Combined Cycle Gas Turbine) (existing plant)

Service
- Heat
- Electricity
  - Electric buses (new items)
  - Bus transport 5.3 million km

Fuel Service
Linköping municipality
Regional energy system 1+2 – integrated system with electric buses

Aalborg University
DENMARK

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#SES4DH2018
Changes in combined system after system integration
<table>
<thead>
<tr>
<th>Heat losses</th>
<th>Biogas driven buses, ICE</th>
<th>Biogas used in CCGT and electric buses for transport</th>
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</thead>
<tbody>
<tr>
<td>Losses through engines and exhaust pipes, 65 major heat losses.</td>
<td>Losses through flue gas from CCGT. Losses through pipes in DHS.</td>
<td></td>
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<tr>
<td>Bus transport efficiency</td>
<td>5,9 kWh (biogas) /km</td>
<td>1 kWh (electricity) /km OR 3 kWh (biogas/waste) / km</td>
</tr>
</tbody>
</table>
Questions?
Changes in combined system after system integration. 

*Conservative efficiency for electric bus - 2 kWh/km*