Cooperation - key to developing biogas projects in Sweden
JTJ – Swedish Institute of Agricultural and Environmental Engineering

Developing knowledge for sustainability with a focus on agriculture, energy and environment
JTI – in short

• Turnover 52 Million SEK
• 59 employees
• Engineers, Agrologists, Animal scientists, Biologists
Owned by Industry and the State

Swedish State

- Ministry of Agriculture
  - Formas
    - JTI Foundation
      - SJMF - Foundation for Agricultural and Environmental Engineering Research
  - Ministry of Finance
    - RISE
      - SP Technical Research Institute of Sweden
JTI Biogas

- Biogas research and development since 1973
- 20 staff members focusing on biogas projects
- We work in all areas of biogas production
  - Substrate management
  - Pre-treatment
  - Biogas process biology
  - Biogas process technology
  - Biogas upgrading
  - Digestate management
- We provide:
  - Desktop feasibility studies and process optimization evaluations
  - R&D projects at lab-, pilot- and full-scale
  - Prototype construction and testing
JTJ Resources

- Experienced researchers and project managers
- Extensive database of biogas data
- Excellent lab facilities
- Both fixed and mobile pilot plants
- Direct access to a full scale plants
- In-house machine-shop
JTI – Other energy related research and services

- Energy efficiency assessments of agro-industrial operations
- RME production and use
- Integration of photovoltaic electricity production in an agricultural context
- Electrification of farm vehicles
- Fossil free agricultural production
- Energy production from horse manure
History of the biogas industry in Sweden

- Industrial scale biogas production during the 2nd World War
- Anaerobic digestion becomes a common part of sewage treatment (sludge stabilization) from the 1960-ties
- Renewed interest and expansion of biogas production in the aftermath of the 1973/74 oil crises
  - Start of biogas R&D at JTI
  - Ca. 15 Swedish on-farm plants + some industrial installations
- Renaissance and intensified build-out of biogas infrastructure from mid 90-ties
  - Centralized municipal plants digesting slaughter- and food waste
  - Focus on upgrading to fuel for municipal bus-fleets
  - On-farm plants built around manure digestion
Comparative strong points of the Swedish biogas industry

- Efficient use of anaerobic digestion capacity at waste water treatment plants
- The Swedish specialty of highly efficient anaerobic digestion of organic waste to generate fuel for municipal transit fleets
- Few but highly optimized agricultural plants focusing on digesting manure
Swedish renewable energy targets

<table>
<thead>
<tr>
<th>RES</th>
<th>% by 2020&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Ktoe by 2020&lt;sup&gt;1&lt;/sup&gt;</th>
<th>% Status 2012&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy sources within the areas of heating and cooling (RES-H)</td>
<td>62</td>
<td>10500</td>
<td>66</td>
</tr>
<tr>
<td>Electricity generation from renewable Sources (RES-E)</td>
<td>63</td>
<td>8400</td>
<td>60</td>
</tr>
<tr>
<td>Renewable energy sources within the area of transport (RES-T)</td>
<td>14</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>Overall share of renewable energy Sources (RES)</td>
<td>50</td>
<td>19700</td>
<td>51</td>
</tr>
</tbody>
</table>


Source 2: Sveriges andra rapport om utvecklingen av förnybar energi enligt artikel 22 i Direktiv 2009/28/EG.
Swedish policy drivers - Biogas

• National environmental goals
  • limit climate change 40% less than 1990 by 2020
  • fossil fuel free transportation sector by 2030
  • no eutrofication and fresh air
• Ban on landfilling organics
  • combustible waste 2002
  • all organics 2005)
• National targets for source separation of organics
  • by 2018 >50% sorce separated at homes, restaurants, industrial kitchens and grocery stores and >40% biologically treated so as to recycle the nutrients and recover energy
• Carbon tax / biogas exempt
  • 0.01EUR / kWh advantage compared to natural gas, 0.06 compared to gasoline and 0.05 compared to diesel
Additional Swedish policy drivers - biogas

• Requiring alternative fuel pump at large gas stations
• 5 years of road tax exemption for biogas vehicles
• Explicit preference given to biogas vehicles when tendering for municipal and regional fleets and services (busses, taxi, recycling collection, home care, etc.)
• Free parking and road toll exemptions for biogas vehicles
• Reduced benefit tax on biogas fuelled company cars
Financial support system

The support system in Sweden is mainly focused on increasing the usage of biomethane as vehicle fuel. The exiting support systems are:

- No carbon dioxide or energy tax on biogas until the end of 2015. Corresponding to around 70 € / MWh compared to petrol and 56 € / MWh compared to diesel of which 24 € / MWh is from the carbon dioxide relief and the remaining part is from the energy tax relief.
- 40% reduction of income tax for use of company NGVs until 2017
- Investment grants for marketing of new technologies and new solutions for biogas during 2010-2016. Maximum 45% or 25 MSEK (~3 M€) of investment cost
- A joint electricity certificate marked between Norway and Sweden. The producer get one certificate for every MWh electricity produced from renewable resources and electricity consumers must buy certificates in relation to their total use. Average price 2013-2014 around 20-22 €/MWh
- 0,2 SEK/kWh (~€ 0,02 / kWh) for manure based biogas production to reduce methane emissions from manure. Total budget 240 MSEK (10 years)
# Biogas Plant Inventory 2013

<table>
<thead>
<tr>
<th>Substrate/Plant type</th>
<th>Number of plants</th>
<th>Production * (GWh/year)</th>
<th>Typical CAPEX (MEUR)</th>
<th>Typical PBP (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage sludge</td>
<td>137 (+2)</td>
<td>672 (+12)</td>
<td>?</td>
<td>10</td>
</tr>
<tr>
<td>Biowaste</td>
<td>23 (+2)</td>
<td>580 (+73)</td>
<td>&gt; 5</td>
<td>5 to 10</td>
</tr>
<tr>
<td>Agriculture**</td>
<td>39 (+13)</td>
<td>77 (+30)</td>
<td>0,4 to 5</td>
<td>5 to never</td>
</tr>
<tr>
<td>Industrial</td>
<td>5 (+/- 0)</td>
<td>117 (-4)</td>
<td>&gt; 1</td>
<td>5 to 10</td>
</tr>
<tr>
<td>Landfills**</td>
<td>60 (+5)</td>
<td>240 (-14)</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>264 (+22)</td>
<td>1 686 (+97)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = energy content in the produced biogas independent of the utilisation

** = increase partly or entirely explained by old plants that have not reported data earlier years
## Biogas Utilisation 2013

<table>
<thead>
<tr>
<th>Utilisation</th>
<th>GWh</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>46</td>
<td>3%</td>
</tr>
<tr>
<td>Heat</td>
<td>521</td>
<td>31% (-2)</td>
</tr>
<tr>
<td>Upgraded to vehicle fuel</td>
<td>907</td>
<td>54% (+1)</td>
</tr>
<tr>
<td>Flare</td>
<td>165</td>
<td>11% (+1)</td>
</tr>
</tbody>
</table>

### CNG/CBG/LNG/LBG as a vehicle fuel
- Number of filling stations: 154 (+58 non-public), 5 for LNG/LBG
- Number of vehicles: 44,000 cars (1%)*, 2200 busses (16%)*, 750 trucks (1%)* of which 50-100 LNG trucks

* = percentage of the national market
- Percentage biomethane/natural gas: 60/40
Biogas trends (1)

30,000 ton 2005 – 307,000 ton 2013

Food waste collection in 190 of Sweden's 290 municipalities
Biogas trends (2)

Biogas utilisation 2005-2013

- Missing data
- Flare
- Electricity
- Heat
- Automotive fuel
Biogas trends (3)

Biogas potential until 2030

Three scenarios with good, moderate or poor development of financial support system, technology and the price of fossil fuels.

1–3 TWh in scenario 3 (poor development)
5–8 TWh in scenario 2 (moderate development)
5–10 TWh in scenario 1 (good development)

Source = Dahlgren S (2013) “Realiserbar biogaspotentiali i Sverige 2030 genom rötning och förgasning”, WSP
Leading the way in waste based biomethane production - how did we manage that despite the challenges??

• It all started with a handful of plants in the mid 90-ties and now we have 23. The key to success has been cooperation

• Political agreement across party lines at local level is crucial

• Municipal and regional governments drive development by:
  - explicit requirements in tendering processes
  - operations directives to municipal corporations

• Broad based local/regional planning projects involving all stakeholders

• Long term contracts for feedstock delivery and biogas production, distribution and utilization as well as digestate use are drawn up
Some other tips:

• Use the advertisement space on transit vehicles to get the positive message out to tax-payers

• Use local air quality arguments – reduction of particulates, NOx, SOx and ground level ozone compared to diesel busses (hits closer to home than GHG-arguments)

• Allow the public (early adapters) to fuel at the biogas pump – this gives you ambassadors in the community and will in time build the biogas market and allow you to build more biogas pumps
Thank you for your attention!

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Common progress of implementation when you are first:

1. Local transit providers orders biogas vehicles (NGV) to fit first phase of biogas production

2. Fuelling stations for local busses and one biogas pump for cars are built with natural gas back-up (starting small but having space for more)

3. If the wastewater treatment plant already have biogas production build an upgrading facility with over-capacity there

4. Start source separation project for municipal organics

5. Start running biogas vehicles on a mix of natural gas and whatever upgraded biomethane you can get from the wastewater treatment plant
Continues from previous slide:

6. Construct first phase pre-treatment facility for source separated organics and anaerobic digesters as close as possible to the wastewater treatment plant and the upgrading plant 7. Link the biogas plant to the upgrading facility at the wastewater treatment with a local gas grid

8. Face out natural gas at the fuelling station as the biogas production and upgrading ramps up

9. Build out biogas vehicle fleet and production capacity gradually as public support, feedstock supply, available space and digestate use allow
The Uppsala example
– what do you do if you are one of the first?

The development of biogas production in my home town of Uppsala is a real life example of how to get the first plant up without an existing market for biogas.

First busses was tried in 1995 and first plant built in 1996 based on slaughter waste WWTP and biogas plant shares an upgrading unit

Expanded in 2008 – now based on SSMO – 50 000 tpy

Today 72 city busses, taxi fleet and private cars run on the biogas from the plant
Biogas upgrading 2013

- 53 biogas upgrading plants in operation: 36 Water scrubbers, 8 PSA, 9 Amine scrubbers.
- 2 membrane units and 1 cryogenic upgrading unit will be taken into operation during 2014
- Biomethane production 2013: 907 GWh/year (191 GWh injected into the grid)
- LBG production: 1 plant produced 34 GWh during 2013
- No power to gas installations exist in Sweden

A complete list of all upgrading plants will be available in November at http://www.iea-biogas.net
Performance and economic data

Median cost (average cost) from nine Swedish biogas plants. Unit: SEK/kWh, $1 = 9.2$ SEK

<table>
<thead>
<tr>
<th>Crude biogas</th>
<th>Upgrading</th>
<th>Distribution in grid</th>
<th>Distribution by road</th>
<th>Refuelling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.54 (0.86)</td>
<td>0.31 (0.32)</td>
<td>0.06 (0.08)</td>
<td>0.12 (0.15)</td>
<td>0.04 (0.07)</td>
<td>0.97 (1.35)</td>
</tr>
</tbody>
</table>

Average price of CNG in Sweden 2012: 1.41 SEK/kWh

Source: SGC report 296 available for free download at [www.sgc.se](http://www.sgc.se)
JTI is Part of the SP-group

Parent company SP and ten affiliated companies: JTI, SIK, CBI, Glafo, SMP, SP Process Development, SP Processum, Asta AB, SP Technical Research Institute of Sweden and SP Fire Research.

Over 1,400 employees

Turnover of 1.5 billion SEK
Stakeholders in JTI

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Biosling
Ekmaco ReAgro AB
DeLaval International AB
Dina Försäkringar
Disperator
Hållbar Consulting, Canada
HIR Malmöhus
HS Kristianstad
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