Market description

Presentation
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Final version

Imprint

Hans Damink
Cornelissen Consulting Services B.v.
Welle 36
7411 CC Deventer
The Netherlands
Tel.: +31 (0)570 667000
Fax: +31 (0)570 667001
http://www.cocos.nl

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Market description
[The current market situation of bio-energy]

Hans Damink
CCS B.V.
Market description

• In this presentation an overview is given of the current market of bio-energy.
• Topics discussed about biogas and wood combustion:
  – Market overview
  – Market trends
Bio-energy Europe
Biogas
Biogas Europe

- Biogas barometer
  - 25.2 TWh electricity in 2009
  - European Renewable energy directive 2009/28/CE + Organic waste management directive 1999/31/CE

- Different focus per country (e.g. Germany: energy crops, UK: landfill biogas)
Biogas in Germany

- More than 6000 biogas plants installed
- Installed capacity = 2300MWe
- Energy crops are widely accepted in the market = no competition with food market due to integration with EU agriculture market
- Reasons increase
  - High technical standards
  - Standardized types of digesters
  - Consolidation of the dry fermentation technology
  - Automation of system control and operation
- Biogas sector exists with specialist engineering, consultancy, plant manufactures and service and maintenance providers.
Biogas in the Netherlands

Digestion
- About 100 digesters realized
- A lot of digesters supported by earlier subsidy rules have financial troubles due to low electricity and gas prices, strongly raised costs for co-fermentates. Often heat is not utilized.
Biogas market trends

• Market trends:
  – Large scale biogas installations
  – Small/micro scale biogas installations
  – Bio methane instead of CHP
  – Biogas hubs
  – Satellite CHP at heat customer location
  – Improved process control
  – Digestate treatment
  – Sustainability of biogas
Large scale production
**Large scale**

- What’s Large scale?
  - Input/year of over 30,000 ton
  - Manure from several farmers
  - Co-fermentates from several farmers
  - Separate business than farm
  - Large scale started in Denmark (early 1980s)

Remark: Optimal scale of installations are country depending, mainly due to different subsidy rules. E.g. current Dutch subsidy rules favor very large installations, current German rules favor smaller plants up to 450 kWe
Large scale

• Why Large scale?
  – Minimization of costs per kWh or Nm3 biogas
    • Higher electrical efficiency of bigger CHP’s
    • Personal cost relatively smaller (enough work for more persons)
    • Bigger biomass quantities => cheaper biomass
    • Better inside in biomass market => cheaper biomass
    • Specialized personnel / operational management
    • More heat utilization possible => more income
    • More options to solve problems (pumping between tanks etc.) => less risks of high deviations in biogas output.
  • Large scale digestate treatment is financial feasible.
Large scale

• Disadvantages/risks
  • High initial project costs for permits (For the Netherlands up to €200.000 and more)
  • Different business compared to a farm
  • Investors often have different interests => chance for conflicts
  • Public opinion often negative (NIMBY syndrome)
  • Financial results very depending on input costs (corn/glycerin etc.) => financial risks
  • Less CO2 reduction compared to small scale digestion due to increased transport distances.

[30/09/2011] [Deventer, The Netherlands]
Large scale

• What’s needed?
  • Investment sums of over €5.000.000,-
  • Consortia of investors including companies with sufficient investment possibilities (Farmers normally do not have sufficient capital to take a large share in the digester)
  • Multiannual contracts with sufficient farmers for manure delivery and biomass delivery
  • A good location for the digester related to biomass availability and heat/gas delivery
  • Early contact with local authorities
Small scale-digesters

• What’s small scale?
  – Biomass input < approximately 5000 ton/year
  – Input often comes from 1 farm

• What’s a mono-digester?
  – In a mono-digester only manure is digested. In some mono-digester small amounts of co-fermentates are added like feed-leftovers.
  – Back to the past of biogas with new technology
Small scale-digesters

• Examples of small scale and mono-digesters in the market:
  - HoSt MicroFerm
  - Thecogas Ecobag
  - GET/Lely AgriModem (4 separate containers)
  - Ludan Bebra “kompactvergister”
  - Biolectric bag with stirling engine
  - Agrofutur container digester
  - Roring/Biovoltaik UDR Picollo digester
Small scale-digesters

AgriModem

Biolectric

Agrofutur

HoSt Microferm

Thecogas Ecobag

Bebra

Roring Picollo
Small scale-digesters

• Why?
  – Closed cycle (emission, minerals, energy)
  – High reduction in NH3 and CH4 emissions from staples due to reduced storage time of manure in stable
  – Sufficient energy produced to cover the farms energy needs. Often energy can be delivered to the grid => green farms
  – Completely integrated in the farm so no separate company (low amount of man hours needed)
  – Cost reduction due to standardization of digesters
  – Permits are easier
  – Low risks because there are no biomass input costs (mono-digesters)
  – Fixed energy costs for the farm
  – No increased digestate production due to co-fermentation.
  – No land for energy crops needed (mono-digesters)
Small scale-digesters

• Why?
  – Manure directly used in digester so no manure storage underneath staple => Better animal health
  – Reduction of pathogenic agents in manure
  – Improved quality of fertilizer
  – Short building period of 3 to 4 weeks
  – Small amount of space needed
Small scale-digesters

• Issues to be solved:
  – Feasibility strongly depends on energy bill of the farm. Often this is still too low to justify the investment. (country depending)
  – Often heat can not be completely be used at the farm. This issue can be solved when small scale digestate treatment including drying becomes feasible or when small scale gas upgrading becomes feasible.
  – Maintenance costs of the CHP has a huge impact on the exploitation costs and so feasibility. => issue solved by bioelectric by using a Stirling engine but at cost of lower efficiencies.
  – Production profile of electricity and heat often do not match with the consumption profile.
Biogas hub

• What’s a biogas hub?
  – A biogas hub is a biogas pipeline which connects biogas producers to other biogas producers and to biogas consumers or an collective upgrading to the gas grid
Biogas hub

• Why?
  – The idea behind a biogas hub is to combine the benefits of large scale and small scale digesters.
    • Better energy utilization for small scale digesters (heat and electricity used at energy consumer so better match possible)
    • Centralized electricity production or gas upgrading => large scale so cheaper per kWh or Nm3 gas
    • Possibility for customer to use biogas directly so no costs for gas upgrading or CHP’s => cheaper energy
    • No gas upgrading or CHP on the farm => less work and better fit to farm work
    • Lower investments for biogas producer (no CHP or gas upgrading installation)
Biogas hub

• Issues
  – Investor(s) needed for investments in pipe line and centralized CHP’s/ gas upgrading installations
  – Difficult to determine the required capacity of pipe line, CHP, gas upgrading installation at start-up.
  – Company needed to exploit and maintain the pipeline (e.g. energy transport company)
  – Contracts needed to guarantee biogas delivery and consumption.
  – Biogas measurements needed for subsidy (e.g. in the Netherlands the biogas hub is added as option in the subsidy rules)
Bio-methane

• What’s bio-methane?
  – Instead of burning biogas in a CHP installation and generating power and heat, the biogas can also be fed into the normal gas grid.
  – Before it can be fed-in the “quality” needs to be improved to natural gas “quality” (biogas => bio-methane)
  – The major difference between biogas and natural gas is the CO2 content.
  – Biogas is called bio methane when it equals the “quality” of natural gas

  – In the Netherlands the subsidy on bio-methane is higher compared to CHP
  – Germany: Potential of 10 billion m3 bio-methane on 10% of agricultural land with 62.000kWh/ha (47 projects realized in Germany)
Bio-methane

• Why bio-methane?
  – Bio-methane is especially attractive when the heat generated by a CHP cannot be used. In that case a higher total efficiency can be reached by using bio-methane since it directly replaces the use of natural gas.
Bio-methane

How?

• Different techniques are available on the market. e.g.:
  • Pressure swing adsorption
  • Absorption by a water or organic solvents scrubber
  • Permeation by membranes
  • Cryogenic upgrading

• The best option depends on size of the biogas plant and availability of heat and electricity.
Bio-methane

• Issues:
  • Common technology often only financially feasible on large scale (>30000 ton/year digester)
  • Capacity on local gas grids often not sufficient (low gas consumption in winter) => need to feed in on transport gas lines of up to 40bar at high costs. Additional investment costs can be more than €100.000,-
  • Early contact with gas transport companies needed to investigate feed-in possibilities and costs.
  • Grid operators need to accept the bio-methane
Bio-methane

Cryogen technology

Pressure swing adsorption

Membrane

Water scrubber
Bio-methane as transport fuel

– When upgraded to bio methane the biogas can replace natural gas in CNG (compressed natural gas) filling stations.
– Natural gas burns cleaner compared to petrol and Diesel
– Filling station can also be placed on a farm
  • Lower investments compared to feeding bio methane into the grid.
  • Risk: enough customers needed to match biogas supply

Tractor coverted to gas by CCS
Profit improvements

To improve the profitability of biogas installations several options are available like:

- Increased biogas production with same biomass input
- Higher yields of energy crops
- Cheaper biomass input (waste products)
- Decrease of own energy demand of biogas plants
- High efficient digester technology to decrease retention time in small volumes.
- More efficient energy production (Fuel cells, micro gas turbines, ORC units)
- Lower disposal costs of digestate (digestate treatment)
Profit improvements

More biomass from same input

– Better process control (pH, volatile acids, gas composition, temperature)
– More constant feed in
  • Amount
  • Composition (measurements)
  • Time
– High performance bacteria (research)
– Single stage to double stage fermentation process => Separation of the hydrolysis and methanisation process => better process conditions
– Remark: 5% more biogas for 1MWel digester can be 60.000€/year
Profit improvements

Energy crops with higher yields

– Research on different breeds of crops
  • Target depends on situation
    – Digester owner: high CH4 m3/ton
    – Producer: high ton/ha yield
    – Own grown for digester: high CH4 m3/ha

– E.g. Corn

<table>
<thead>
<tr>
<th></th>
<th>Vers ton/ha</th>
<th>Ds ton/ha</th>
<th>Water ton/ha</th>
<th>CH4 m3/tonos</th>
<th>CH4 m3/ha</th>
<th>CH4 m3/tonvers</th>
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<tbody>
<tr>
<td>Ras 1</td>
<td>55</td>
<td>19</td>
<td>36</td>
<td>370</td>
<td>6700</td>
<td>123</td>
</tr>
<tr>
<td>Ras 2</td>
<td>80</td>
<td>23</td>
<td>57</td>
<td>365</td>
<td>8000</td>
<td>100</td>
</tr>
<tr>
<td>Ras 3</td>
<td>95</td>
<td>22</td>
<td>73</td>
<td>300</td>
<td>6400</td>
<td>67</td>
</tr>
</tbody>
</table>
Profit improvements

Cheaper biomass input

- Co-fermentates costs is large part of operational costs
- Waste products => from costs to gate fees
- E.g. Land manage grass, straw

- Issue: low quality due to high content of fibers and lignin. (Lignocelluloses)
  => Pre-treatment is necessary to increase the biogas yields.
- The aim of pre-treatment is to change the characteristics of the biomass to fasten and improve the enzymatic hydrolysis.

Remark: Scans are needed to check if pre-treatment is energetic and financial interesting. Compare energy consumption vs. additional biogas/methane gain
Profit improvements

Cheaper biomass input

Several pre-treatment techniques are investigated like for example:

- **Thermal:** steam explosion, hot water extraction (high heat demands)
- **Mechanical:** shredders, mills, extrusion techniques to reduce size of and disintegrate the biomass (high electrical energy consumption)
- **Chemical:** Use of acids, bases or oxidizing compounds to brake up large chains. (e.g. sulfuric acid, hydrogen peroxide, ozone)
- **Biological:** enzymes, silage additives
- **Ultrasonic:** microwave

- E.g. Silage additive on maize results in 10 to 20% more CH4/ ton oDS at costs of about 1,5€/ton maize
Profit improvements

Digestate treatment

• In areas where there is a surplus of manure it can be beneficial to treat the digestate.

• By processing disposal costs can be changed to benefits. An assessment is needed to check which steps of digestate treatment are financially feasible:
  – Determine which nutrients you need to get rid off?
  – Investment costs
  – Energy costs
  – Maintenance costs
  – Disposal costs of digestate
  – Benefits / reduced disposal costs of output (new market so often difficult to determine)
Profit improvements

Digestate treatment

- Step 1: Separation (decanter, screw press)
  - To split the digestate into a thick and a thin fraction
  - DM content in thick fraction is about 15 to 40% depending on technology used

<table>
<thead>
<tr>
<th>Liquid phase</th>
<th>Manure separation</th>
<th>Solid phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% Ammonium</td>
<td>5 %</td>
<td></td>
</tr>
<tr>
<td>5 % organic Nitrogen</td>
<td>95 %</td>
<td></td>
</tr>
<tr>
<td>80% Potassium</td>
<td>20 %</td>
<td></td>
</tr>
<tr>
<td>10% Methane</td>
<td>90 %</td>
<td></td>
</tr>
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</table>

Variable content

- 50-1 % Phosphorus
- 80-90 % Volume

* depending on the application of precipitants
** depending on chosen machinery
Profit improvements

Digestate treatment

– Optional step = Reversed osmoses + Ultra filtration Process
  • Process the thin fraction further (removing of all minerals)
  • Minerals can be used to replace fertilizer
  • Purified water can be disposed
  • Complex and sophisticated technology
  • Only feasible on large scale
  • High energy demand
Profit improvements

Digestate treatment

– Optional step = Drying of thick fraction
  • High heat demand (should only be done in combination with a CHP or external heat supplier)
  • Reduced transport cost thick fraction
  • Can be sold as fertilizer or burnt
  • Good results seen with using the dried fraction in staples (animal health)
Profit improvements

Digestate treatment

Filtration  Reversed Osmoses  Drying
Wood Combustion
Wood Combustion

Market overview:

Bio-energy EUBIONET3
Wood Combustion

Market overview:

- Other biomass
- Herbaceous & fruit biomass
- Used wood
- Use of refined biomass
- Spent liquors
- Solid ind. wood residues
- Firewood
- Forest residues

48% of resources in use

[30/09/2011] [Deventer, The Netherlands]
Wood market trends

Market trends:

- Large scale wood gas / Rankine CHP plants
- Small scale wood gasifiers
- Wood pellets / chips
- Other utilization techniques
  - Torrefaction
  - Pyrolysis (development stage)
CHP (Wood gas)

- Wood gas is produced by gasifying the gas (“burning” at high temperatures with oxygen deficiency)
- Wood gas is a syngas consisting mainly out of H2, CO, N2).
- After cleaning wood gas can be burned in a gas-engine or gas-turbine => heat and electricity.

- Different option: process the gas to liquid fuel (Fischer-Tropsch process)
- Installations from 0,5 MWe up to 6MWe
- Overall efficiency of 80% possible (heat and electricity)
Another option is the combination of a steam boiler and a steam turbine (Rankine cycle)

- Wood is burned and in a boiler steam is made
- Steam is used to power a conventional steam turbine which powers and generator => electricity
- Also Organic Rankine cycle is possible (uses organic fluid instead of water)
Wood gas

Wood fired power plant (Organic rankine cycle)
Wood gasifiers

- Wood gasifiers burn the wood in two stages/chambers:
  - First step: gasification with oxygen deficiency in the first chamber
  - Second step: Combustion of the released gas in the second chamber.

- Wood gasifiers have higher efficiencies compared to boilers with single stage combustion system.
Wood pellets

Development of pellet-based heatings in Germany

Source: Deutsches Pelletinstitut (DEPI), based on the values of Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) and the Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e.V. (BDH); Image: BMU / Bernd Müller, as at: July 2010; all figures provisional
Wood pellets

- Wood pellets have standardized characteristics and features
- Benefit: Standardization of equipment possible (especially interesting for small scale appliances)
- Disadvantage: more expensive than wood chips

Wood pellets

Wood chips
Torrefaction: heating of wood to 200 – 300 degC with absence of oxygen.
• Embrittles the material so it can be grinded (for use in coal fired power plants)
• Suppressed uptake of moisture => improved storage characteristics

Torrefaction must be seen as a pre-treatment of the woody biomass to improve the quality
Pyrolysis

In pyrolysis the wood is heated to 450-600 degC in the absence of air.

- Slow pyrolysis (10 to 20 minutes) => charcoal with 60% of the heating value of the biomass
- Fast pyrolysis (<1 sec) => pyrolysis oil (oil can replace fossil oil)

Fast pyrolysis is still in the development phase. Slow pyrolysis is used on a large scale to produce activated carbon.
Sources

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