Biomethane the Climate-friendly Substitute of Natural Gas

Salzburg, August 29th 2011
Dr. Thomas Stephanblome
Agenda

A: Biomethane: principles
B: The German market
C: Biomethane Production
D: Sustainability / Reduction of greenhouse gas emissions
Production of biomethane

- Biomethane injection uncouples the production and usage of bioenergy
- Biomethane injection enables usage of bioenergy even in metropolitan areas
Why upgrading and grid injection?

**Yesterday**
- biogas
  - (local CHPs)

**Today**
- biomethane
  - (purification + injection)
  - gas pipe

**NEW**
- electricity (CHP)
- heat (CHP, boiler)
- fuel
- biogas plant

- few locations with full heat utilisation
- optimised heat utilisation = high efficiency
- high versatility of usage

**Why upgrading and grid injection?**

A: Biomethane: principles
Germany’s biomethane targets and potential

- EU directive to produce energy from renewable sources
- Target for Germany: 18% share of renewables by 2020
- Target set by German government in 2007 (IEKP):
  - 6 bio m³ annual injection by 2020 (= 60 TWh/a)
  - 10 bio m³ annual injection by 2030 (= 100 TWh/a)
- Potential for biomethane production in 2030 calculated at 105 – 174 TWh/a (correlating to 11 - 18% of natural gas consumption in 2009)

Source: Wuppertal Institut, IE-Leipzig, FHG-Umsicht, GWI in DVGW/BGW-Biomasse-Studie, 2006; dena 2010
The German biomethane market: ~ 60 TWh/a in 2020

Key takeaways

- **CHP market**: Source: dena-study “German biomethane market for heat & CHP”
  - Potential is inline with E.ON analysis of this market segment
  - EEG amendment 2012 is expected to bring improvements

- **Residential heating market**: Source: dena-study “German biomethane market for heat & CHP”
  - EEWärmeG amendment 2011 is expected to bring improvements

- **Vehicle fuel market**: Source: dena-study “Vehicle fuel market for natural gas and biomethane”
  - Slow development because of limited infrastructure (filling stations, gas cars,..)
Legal framework

- **Renewable energy act**
  - fixed feed-in tariffs for electricity produced from biogas or biomethane
  - feed-in of renewable energy has primacy over conventional energy
  - allocation of costs to consumers (EEG-Umlage 2011: 3.5 ct/kWh)

- **Renewable heat act**
  - house owners obliged to fulfill a quota of renewable heat upon renovation or new building
  - use of a biomethane / natural gas mix is one option to fulfill quota

- **Grid access regulation**
  - definition of responsibilities of biogas plant operator and gas grid operator (including definition of grid connection costs and their split between plant and grid operator)
Grid access regulation (Gasnetzzugangsverordnung)

- Obligation for grid operators to connect biogas plants on demand with fixed time schemes
- Biogas plant is responsible for upgrading to (general) natural gas quality (according to standards DVGW G 260/262)
- Grid operator is responsible for adjustment to local grid conditions (e.g. by adding propane or air to adjust the calorific value)
- Grid operator is responsible for gas quality control, metering, and compression
- OPEX and CAPEX for injection station and connection pipeline paid by gas grid operator
- Fixed connection fee of 250.000 € to be paid by biogas plant operator (some exemptions if connection pipeline is longer than 1 km)
Challenges to biomethane market

- different economics for biomethane from energy crops, agricultural residues or waste
- EEG restricts economic biomethane utilisation to small CHP
- no financial incentive to use in large scale CHP and CCGT, or as fuel for transportation
- financial incentive to use for domestic heating only in one state (of 16)
- meeting the Government target (6 bio m³ by 2020) requires increase from todays 50 biomethane plants to appr. 1,000 plants in 2020 (= building of 100 plants per year)
- target is very ambitious and can only be achieved if next amendment of the renewable energy act (EEG) betters the economical situation of biomethane plants
Biomethane plants in Europe (2010; existing & planned)

- 110 biomethane plants, at least 67 with grid injection

Source: www.biogaspartner.de
Biomethane plants in Europe (2010)

- Biomethane projects depend heavily on national incentive schemes
- European biomethane feed-in capacity 31,700 m³/h (2010)
- E.ON’s feed-in capacity 8,000 m³/h (Germany: 5,900 m³/h; Sweden: 2,100 m³/h)

Source: dena, www.biogaspartner.de 2010
E.ON biomethane projects in Germany

- Aiterhofen: 92 GWh/a, in operation since 09/2009
- Könnern: 150 GWh/a, in operation since 09/2009
- Einbeck: 50 GWh/a, in operation since 09/2009

E.ON assets
long term contract
Biomethane plant Aiterhofen

- Annual biomethane production: 90 GWh$_{H_2}$/a
- Substrates: 80,000 t/a (energy crops)
- Biogas production and upgrading built by Schmack Biogas
- Upgrading by PSA
- Commissioning 09/2009
Biomethane plant Einbeck

- Annual biomethane production: $50 \text{ GWh}_\text{H}_2/\text{a}$
- Substrates: 45,000 t/a (energy crops)
- Biogas production and upgrading built by MT Energie
- Upgrading by amine scrubber
- Commissioning 09/2009
Sustainability of biomethane

- renewable energies are not a priori sustainable
- sustainability requires protection of soil, water and air
- keys to sustainable production:
  - efficient utilisation of substrates
  - high versatility of substrates including organic waste
  - production of energy crops with high agricultural standards (“Cross Compliance”) and high energy yield per area cultivated
  - low emissions on production level
  - high CO2-avoidance on utilisation level
Biomethane has highest versatility of input materials

source: KWS
Crop rotation for sustainable production of energy crops

- Extra advantage: lower pests pressure

(Schmack 2008)
Biomethane has highest energy yield per area

- Efficiency compared to diesel *
- Efficiency compared to gasoline *
- Efficiency compared to natural gas *

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Distance (km)</th>
<th>Efficiency</th>
<th>Farm Area Needed for 100,000 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiesel (RME)</td>
<td>23,100</td>
<td>91%</td>
<td>4.3 ha</td>
</tr>
<tr>
<td>Bioethanol</td>
<td>23,100</td>
<td>66%</td>
<td>4.3 ha</td>
</tr>
<tr>
<td>BTL (Sunfuel)</td>
<td>61,100</td>
<td>93%</td>
<td>1.64 ha</td>
</tr>
<tr>
<td>Biomethane</td>
<td>67,200</td>
<td>100%</td>
<td>1.49 ha</td>
</tr>
</tbody>
</table>

* base: fuel consumption of Opel Zafira (gasoline, diesel, CNG)
** source: Fachagentur Nachwachsende Rohstoffe

D: Sustainability and reduction of GGE
Crop production accounts for appr. 65% of GHG emissions

- GHG potential
  - CO2 = 1
  - CH4 = 25 CO2 equivalents
  - N2O = 298 CO2 equivalents

- mineral fertiliser is largest source of greenhouse gases; will be minimised by using digestate as organic fertiliser

- petrol consumption is ecologically not crucial but important for economics

- N2O emissions yet based on assumptions

- pesticides are climate-wise irrelevant (but energy crops require less pesticides anyway)

source: 1IPCC 2007, diagram Ifeu 2008 „Basisdaten zu THG-Bilanzen für Biogas-Prozessketten“
GHG emission of biomethane depends on plant size and design.

- Small plants have higher emissions per kWh than large plants.
- Best practice plant design and operation cuts emissions by >50%.
Method to calculate GHG savings

<table>
<thead>
<tr>
<th>CO2 emissions of biogas/biomethane</th>
<th>applications and their efficiencies</th>
<th>GHG emissions of (avoided) reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>152 g CO₂ /kWh, Hi</td>
<td>biogas in local CHP with no heat utilisation</td>
<td>38% power 62% loss 572 g CO₂/kWh,el (power mix Germany 2008)</td>
</tr>
<tr>
<td>54 g</td>
<td>biomethane in heat-steered CHP, full heat utilisation</td>
<td>38% power 43% heat 339 g CO₂/kWh,th (heating mix Germany 2007)</td>
</tr>
<tr>
<td>54 g</td>
<td>biomethane in calorific boiler</td>
<td>91% heat 9% loss</td>
</tr>
</tbody>
</table>

Sources: Ifeu 2008, UBA 2010, DBFZ 2008, E.ON own data
GHG savings of biogas/biomethane applications

- biomethane has near equally high GHG savings in all applications
- in CHP maximum heat utilisation is crucial
Summary of advantages of biomethane

• Biomethane is a dispatchable and storable energy source (unlike wind and solar power) with the highest end usage versatility of all renewable carriers: fuel for transport, heat and electricity

• Biomethane is available year-round (24/7); plants run in base load

• Anaerobic digestion has the highest energy yields per area and the highest versatility of input materials:
  - dilute organic waste, solid organic waste, wet crops, dry corn
  - root, stem, leaves and fruit

• Anaerobic digestion has a closed cycle of matter: nutrients from biomass return as organic fertiliser to the fields

• Biomethane in all usages has a high climate change mitigation effect
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